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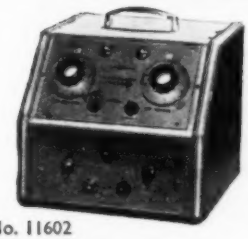

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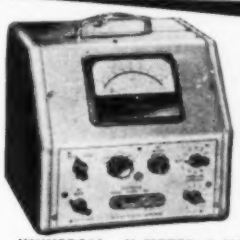

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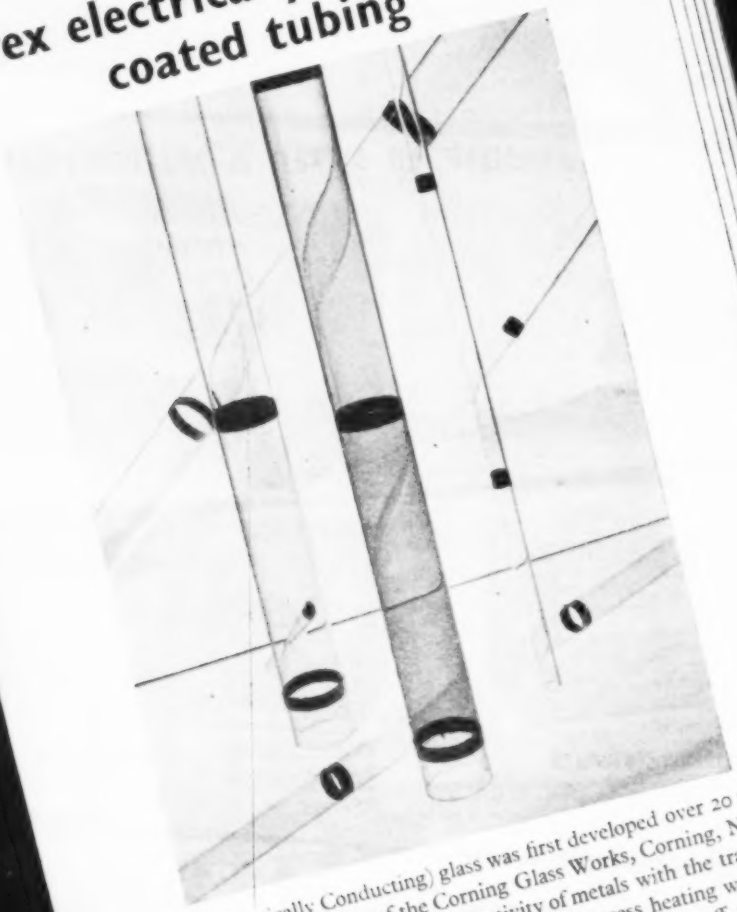

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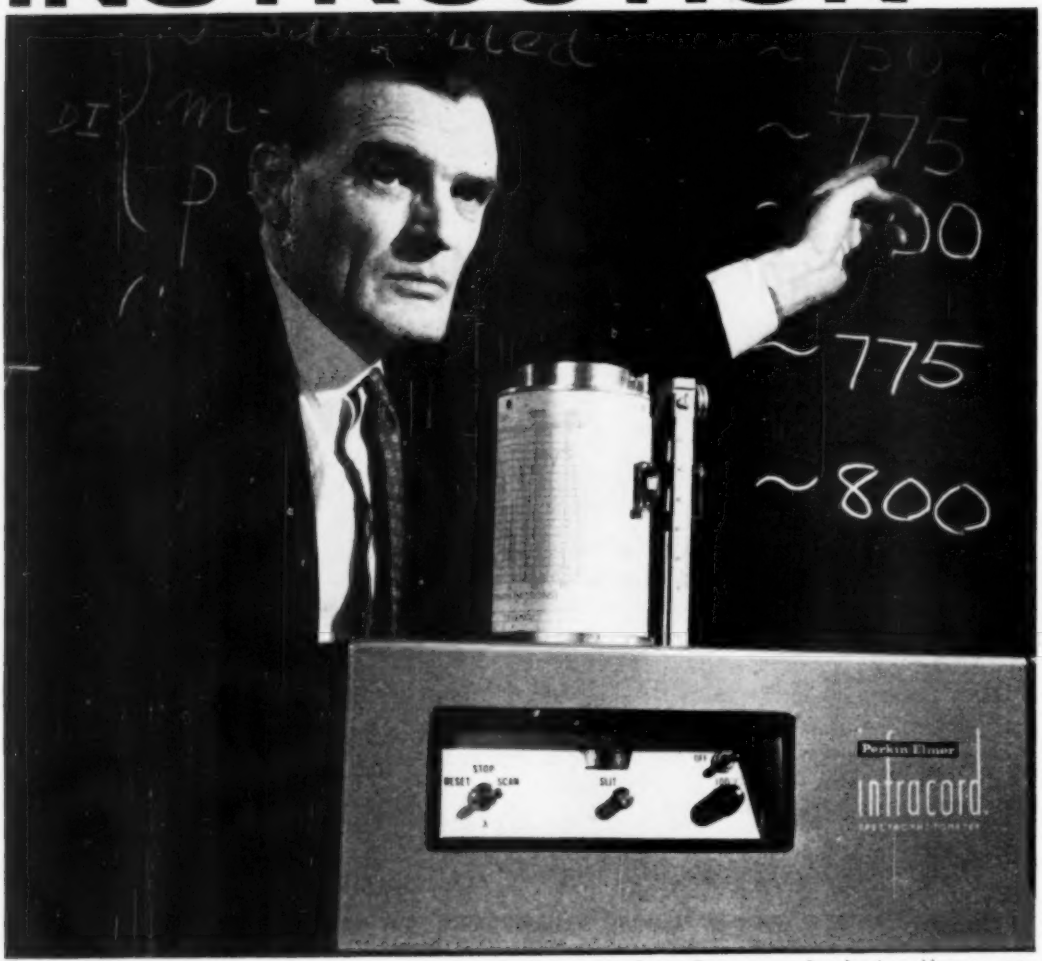

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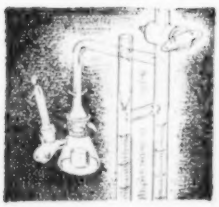
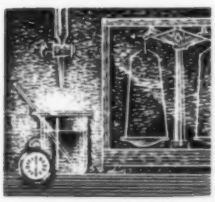
a glance at yesterday in relation to today



IN FEBRUARY—(1914)—investigation of the chemical structure of nucleic acids continues. Two years ago, Walter Jones (Johns Hopkins) reported the formation of guanylic acid from the hydrolytic action of pig pancreas on yeast nucleic acid, but this experiment "can be repeated with only occasional success. . . ." By substituting Lebedew's commercial yeast for pig pancreas, Jones and Richards have now developed a procedure "which involves no judgment on the part of the experimentor." Since by this new method, guanylic acid is invariably obtained as an end product, it is definitely a constituent of yeast nucleic acid.[1]

Though yeast nucleic acid is still the best source of nucleotides, the methods for isolating them have improved immeasurably since 1914. By modern techniques employing specific enzymes and ion exchange chromatography, Schwarz BioResearch now produces GMP, GDP and GTP, as well as guanylic acid (mixed 2', 3' isomers). We also produce many other components of the nucleic acid molecule (both DNA and RNA): nucleotides, nucleosides, purines and pyrimidines, sugar and sugar phosphates — many also available radiolabelled.



IN FEBRUARY—(1934)—a famous physical chemist writes about the effects of heavy water upon tobacco seeds, yeasts, molds, flatworms and mice.[2] G. N. Lewis finds that heavy water is tolerated in high concentrations by the lower organisms, but the rate of vital processes appears to vary inversely with the percentage of H^2. This is not surprising, since substitution of H^2 for H^1 reduces the rate of *all* physico-chemical processes.

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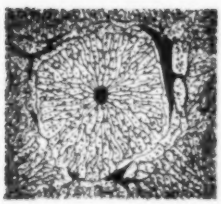

IN FEBRUARY—(1950)—Sanadi and Greenberg[3] report on the metabolism of tyrosine and phenylalanine in experimental diabetes. These had previously been considered ketogenic substances since they increase ketonuria in phlorhizinized animals and produce acetoacetate when incubated with liver slices. However, when the authors administered C^{14}-labelled phenylalanine and tyrosine to phlorhizinized rats, both the urinary glucose and ketone bodies were found to contain radioactivity. Therefore, the two amino acids should be considered *glycogenic* as well as *ketogenic*.

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1. Jones, W., and Richards, A. E.: The partial enzymatic hydrolysis of yeast nucleic acid. J. Biol. Chem., *17*:71 (Feb.) 1914. 2. Lewis, G. N.: The biology of heavy water. Science *79*:151 (Feb. 16) 1934. 3. Sanadi, D. R. and Greenberg, D. M.: Metabolism of C^{14}-labelled tyrosine and phenylalanine in phlorhizinized rats. Arch. Biochem. *25*:257 (Feb.) 1950.

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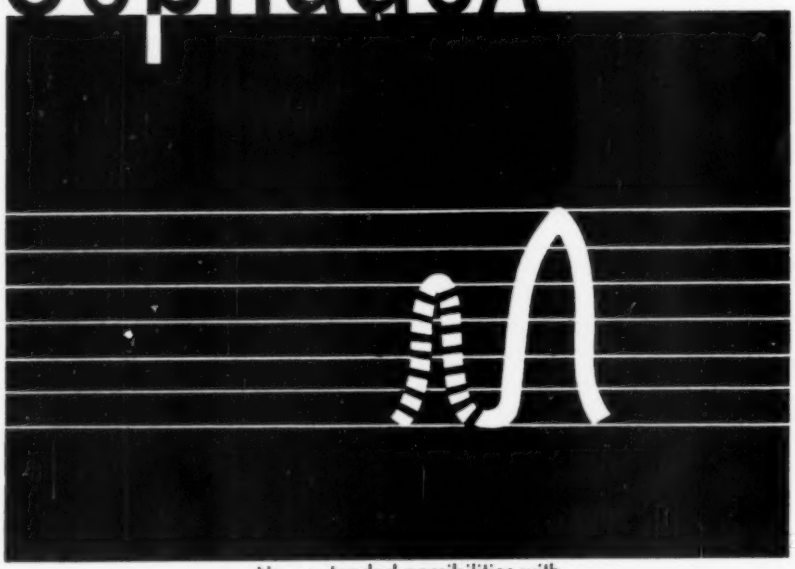

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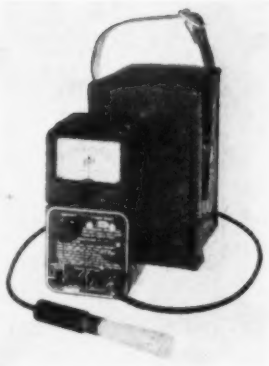

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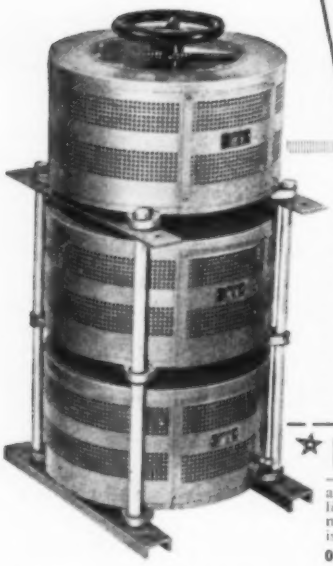

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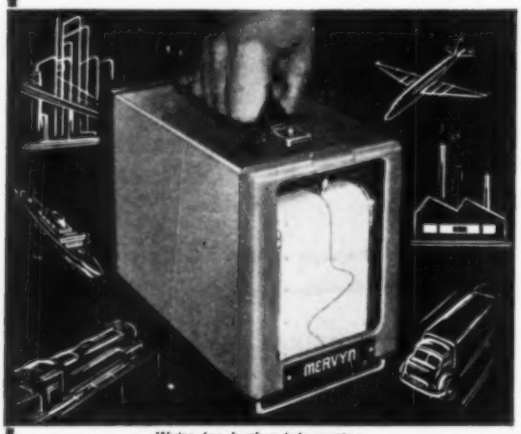

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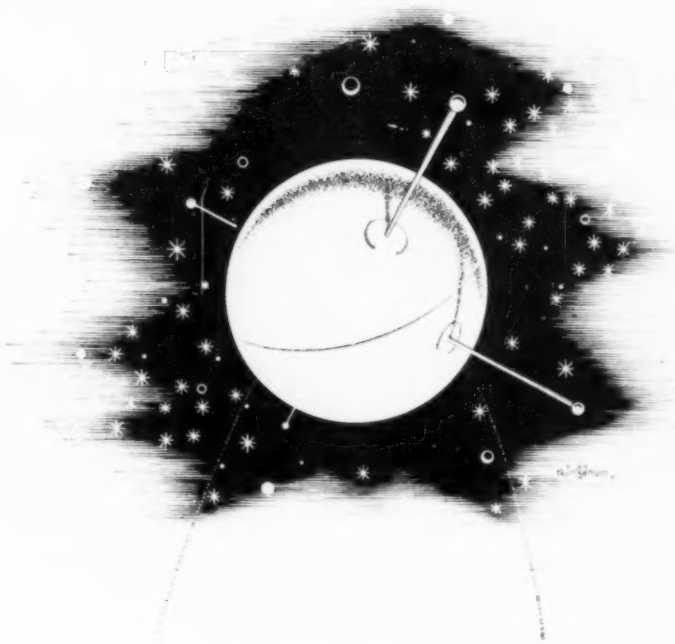

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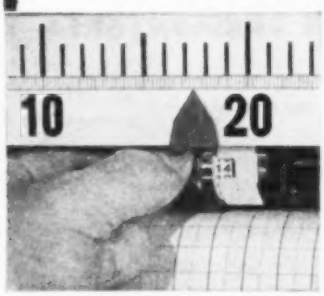

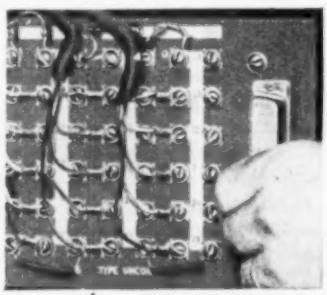

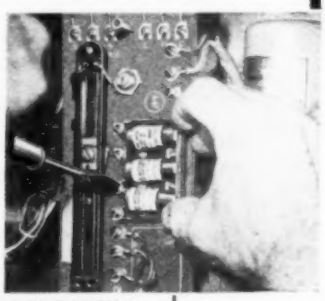

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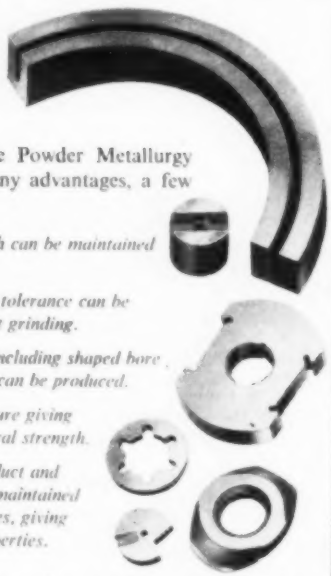

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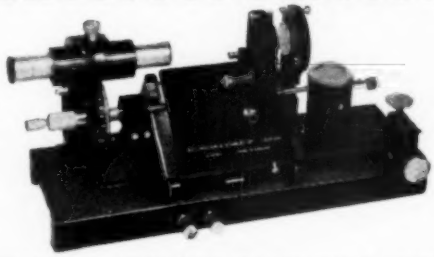

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STRENGTHENING SCIENCE AND TECHNOLOGY

MORE than a year has elapsed since an eminent group met in Paris to discuss ways and means of strengthening science in the Western world. As scientists with executive ability, they had been selected from countries within the North Atlantic Treaty Organization. Motives for bringing together such a study group were prompted partly by the Cold War. However, "even if there were no Soviet menace . . . the demands of the populations of the Western countries for a higher standard of living, for relief from toil and drudgery, for increasing health of body and mind, can only be met by the advance of science and its applications in technology". A report was issued*, and the gist of it appears in a leading article of *Nature* (188, 880; 1960). During December 19–23, countries of the Middle East and North Africa sent representatives to a meeting in Cairo to confer on ways of invigorating science and technology in their respective lands. This was held under the hovering auspices of Unesco, and the conference is reported on p. 362 of this issue of *Nature*. It is of interest to examine critically some of the points which arose from these meetings. Although the participants in the two meetings came from countries which vary widely in the degree of technological development, many of the obstacles encountered are common to all.

The outcome of these deliberations is very cogent and deserves praise. In particular it is heartening to see a resolution from the Cairo meeting (No. 17): "That all efforts and results reached by science should be used solely to help humanity. . . ". It has never been denied that a vast amount of scientific effort is directed according to military considerations. That such research lends an inevitable impetus to the scientific quest for truth is not wholly valid. The effect is of second-order importance—almost trifling, in fact. Perhaps this resolution portends that scientists, realizing the implications, will begin to emerge from their research cartels, exercise a certain political awareness and give a resounding, concerted negation to what amounts to a greater and greater refinement of preparation for cataclysmic war.

To achieve scientific and technological prowess, education is necessary, so much has been said about instructing the would-be scientist. In the Paris meeting it was considered that the logical place to start moulding the scientist and technologist was in the secondary school. That the claims of science and technology were very often subordinated to those of traditional courses in the humanities and law was deplored. Scientific interest should be aroused in the pupil. Quite often this was inhibited by conservative proclivities of teachers devoted to "inert ideas". Pupils should be able to relate the substance of their courses to what science is achieving, hence curricula should be topical. Sir John Cockcroft believes, quite rightly, that to strengthen Britain's science and technology it is more important to do so in the universities than anywhere else at the present time. On January 3 at Nottingham he stated that Britain needs a major new technological university of at least five thousand students if it is to catch up with the U.S.S.R. and the United States. Although during 1958–59 British students of the arts outnumbered slightly those reading science and technology, it seemed likely that by the late 'sixties there would be about twice as many technologists as students of the arts; the absolute number of the latter is not likely to diminish. He also alluded to a point which arose in the Paris meeting, namely, the possible foundation of an Atlantic institute of science and technology which would be a combined effort from countries of the North Atlantic Treaty Organization.

These various points on education for scientists and technologists are well taken. But perhaps a greater stress should be placed on quality rather than quantity. More should not mean worse. Large technological institutes have their place, but, after all, the birth of the Berlioz orchestra has never displaced the aesthetic need for the string quartette. The dangers of egalitarianism and conformity in large institutions are immense. In his book, *Teacher in America*, Prof. Jacques Barzun of Columbia University, New York, has pointed out the sorry plight of education in the United States. He feels that education should be a hand-to-hand affair. He refers to the 'preceptorial' system used successfully at Princeton University. This is a small university relative to the massive institutes of technology, but its educational calibre, both in the sciences and in the humanities, is unsurpassed in the United States. The preceptorial system is similar in principle to the tutorial system of Oxford and Cambridge, and possibly a few other universities, whereby students receive instruction in small groups. Standards of all degrees should be kept high, otherwise they become meaningless. It is quite revealing to examine some theses toward research degrees—their tortuous manipulation of symbols, numerous data, wealth of bibliography, but sadly a paucity of ideas. One is tempted to say with Virgil:

> "Why not apply yourself to useful tasks,
> Plait wicker crates and baskets of soft reeds?"

The probing spirit should be respected for what it is; not make a passport to probe, appended to it, a *sine qua non*. Perhaps atmosphere is lacking, and this could be partly ascribed to the passion for the research 'project'. The meditative approach was used by great men of science in the past—"What interesting questions does Nature pose and what is the minimum amount of experimental equipment

* Increasing the Effectiveness of Western Science. Pp. III + 19. (Brussels: Fondation Universitaire, 1960.)

needed to answer them ?"—and it resulted in great works. It is well worth a visit to the Cavendish Laboratory to see with what little equipment so much was accomplished.

The criticism levelled at academic institutions which encourage the humane tradition in education is perhaps not entirely called for. Science should not displace the humanities but be an adjunct and partner. The scientific method is one way of approaching truth progressively—there are other ways, equally laudable. An educated man should have reasonable command over all these. How disquieting to envisage a growing host emerging from technological institutes, all thinking in the same way, all with similar utterance—in effect, a band of æsthetically impervious, socially unaware, but adept barbarians who will not deem any knowledge worthy unless it be formulated exactly. It is Anton Tchekov who tells Grigorovitch he had come to the conclusion that "an artist's instinct may sometimes be worth the brains of a scientist, that both have the same purpose, the same nature, and that perhaps in time, as their methods become perfect, they are destined to become one vast prodigious force which now it is difficult even to imagine".

That science syllabuses are kept up to date and the pupil's enthusiasm stimulated by emphasizing present scientific achievements is necessary. However, it is well to point out to the pupil what fundamental scientific thought means as opposed to the technological aspects. His imagination is captivated easily by the glamour of rockets and satellites. This to him is science *par excellence*. However, if he were to realize that it is the genius of Newton's laws plus a fuel of large enough specific impulse, developed with abundant funds, which enables 'rocketeers' to 'aim at the stars', it would sharpen his critical appreciation of scientific merit.

The dilemma faced by a research worker seeking specialized information in his field was discussed by the group in Paris and at the meeting in Cairo. The recent decline in adequate documentation was blamed on "the mushroom growth of scientific publications" and on poor methods of classifying publications. Unesco and allied organizations will attempt to improve the situation by unifying editorial practice, by instituting a single international indexing system, by requesting authors to submit abstracts with their research articles and by discouraging new publications. How avid scientists and engineers are to-day to get into print ; to place their morsel on the altar of fame ! Inundated by this spate of material of greater or lesser virtue, one cannot help but yearn for the modesty of the Darwins and Faradays of the past. To the solutions which Unesco will attempt, it seems appropriate to add a wily suggestion given by Mr. L. J. F. Brimble during an address to the Royal Society of Edinburgh on January 11, 1954. He felt that every scientist intending to publish research should be posed with the following questions : "(1) Are you sure you have said what you want to say ? (2) Have you said it in the minimum number of words ? (3) Is it worth saying at all ?"

EVOLUTION

Evolution After Darwin

Edited by Prof. Sol Tax. Vol. 1 : The Evolution of Life—Its Origin, History and Future. Pp. viii+629. Vol. 2 : The Evolution of Man—Man, Culture and Society. Pp. viii+473. (Chicago : University of Chicago Press ; London : Cambridge University Press, 1960.) 80*s*. net each volume.

Evolution

Its Science and Doctrine—Symposium presented to the Royal Society of Canada in 1959. Edited by Thomas W. M. Cameron. ("Studia Varia" Series, Vol. 4.) Pp. xi+242. (Toronto : University of Toronto Press, 1960. Published for the Royal Society of Canada.) 40*s*. net.

THE first of these books (Vols. 1 and 2) forms part of a series of three volumes of Darwin entenniale essays written by well-known scientists as the basis for discussions which took place between the writers during the Darwin centennial celebrations at the University of Chicago, 1959. The third volume, *Issues in Evolution*, is not included in this review. Altogether there are 42 essays and some of them are very long, up to 80 pages and with about 200 references. These essays are quality writings, perhaps designed more for experts than for general readers, who would require a large background knowledge to appreciate all of them.

About a year ago I heard a publisher publicly declare that evolution as a topic of concern was dead. I suppose this is true in terms of the old Darwinian controversies. It seems that there is now a more settled and intelligent view of the matter—the theory has been assimilated into the general intellectual background. The publisher's statement is certainly not true when we turn to biological literature, and the symposia presented by the books reviewed are evidence enough of the professional interest in evolution. There are still plenty of teaching and research biologists who would answer the question "Is evolutionary theory important ?" with "Yes, I suppose so". They accept it, but are not particularly stimulated by it. It is precisely to people like this that the present symposia should be of importance, if only because these essays range over such a very wide field. The essays will either provoke the 'bandwagon' biologist's anger or his acceptance, but they will not leave him unmoved.

These essays show unmistakably how intertwined all the sciences are. Biology is not just the study of the grosser aspects of plants and animals, but now takes in all empirical approaches to knowledge in its phenomenological aspects. This all springs from the uniqueness of man, from mind if you like, but, as some of the essays show, this knowledge stops there. A disheartening feature of the books as a whole is that no indication is given of a further step in the study of life, particularly in relation to man, where much of the cultural tradition of the older scholasticism, which rendered possible the development of the newer scientific scholasticism, is ignored. An essay by Teilhard de Chardin, if it had been possible, or by someone of similar cosmic outlook, would have completed the story of evolution as set out in these two volumes. An essay taking in man as a biological and as a spiritual creature would have set a truer balance between the essays. The lack of such a balance has destroyed the harmony of the whole

plan, and this disharmony is emphasized in several of the essays in which a materialistic approach (as distinct from a necessary mechanistic approach) is maintained. Other essayists, such as C. H. Waddington, are not so dogmatic. He contends, reasonably enough, that the evolutionary theory does not critically answer the question of the acceptance or rejection of theism or atheism. It must be settled in some other way, and so he is not concerned with it. But if evolution is the process basic to the whole of the cosmos, and it is to this view that a wider view of evolution leads, then the question of theism or atheism is of the utmost importance, for either evolution leads to one or the other concept or the process of evolution lacks meaning for man and is relatively unimportant.

While all the writers justifiably emphasize the importance of the works of Charles Darwin and many of them seek explanations through natural selection, some writers tend to discuss the operation of selection in fields where there is no evidence of its operation. An interesting feature of the books as a whole is that the importance of selection is not now so overemphasized, except perhaps by a few extreme selectionists, but the importance of a balance between the well-known factors of evolution is acknowledged.

In the essays on the evolution of man, L. S. B. Leakey gives an interesting account of the new genus *Zinjanthropus* and its importance. But in some of these essays it is clear that there is a general attempt to lessen the Cartesian split between body and mind and hence between man and lower animals. The method of doing this would seem to be unsound, for man is played down as it were, his really important attributes are glossed over in favour of finding him a place in a zoological classification, while at the same time the animal is played up until we are nearly led to think that there is scarcely any fundamental difference between man and animal. But, to a non-Cartesian who still holds to the spirit of the Thomists that the phrase *animal rationale* is meaningful, the evidence for the smallness of the gap between man and animal does not seem excessively strong. Although to some biologists the term 'man' may be a confounded nuisance, to other people it is far more than a colloquial word. I was beginning to think that perhaps the infra-human hominoids were more human than I myself, until I was brought back to earth by recalling a sentence of Humphrey J. T. Johnson that there is a wider difference "between a man and a gorilla than between a gorilla and a daisy. The one is as incapable as the other of creating civilization".

All these essays are interesting and, above all, most stimulating. They are full of sound information and points of view and cover most aspects of evolutionary theory and its implications, but not all. An important essay which is missing from this work is one which discusses the validity of the fundamental assumptions of all evolutionary theory, the value of the mathematical models, particularly in the genetical field and the tautology of selection. There are biologists, such as W. R. Thompson, who doubt some of these assumptions, such as that embodied in G. G. Simpson's twisted phrase of "the genetical relationships that are reconstructed as phylogeny". Indeed, Bernard Rensch has contributed a very valuable essay on the laws of evolution which would have better earned its *droits de cité* if it had been preceded by an account of the methodological bases of evolutionary theory. A critique of evolutionary theory has long been needed and the opportunity for its production was given by these centennial symposia, but, at least in these books, the opportunity was lost.

Evolution: Its Science and Doctrine is also the result of a symposium on evolution organized by the Royal Society of Canada to commemorate the Darwin centenary and held at the annual meeting of this Society in 1959. The book contains twenty essays, all by Canadians. These essays do not cover such a wide field as those in the Chicago symposia, and most of them are straightforward accounts of biological, geological, biochemical, sociological, philosophical and cosmological aspects of evolution. They are less for the expert than for the general trained reader. They are non-controversial except for one of them. This last essay gives a biochemical outlook on evolution which is so dogmatically materialistic and narrow in its interpretation as to lower the intellectual level of the book as a whole. It is, however, offset to some extent by an essay in French on philosophy and evolution. It is unfortunate that this symposium did not include an essay on the evolution of man. In general this is an interesting book containing much useful information and with a balanced outlook on evolutionary matters.

P. G. Fothergill

A FARRAGO OF EARTH HISTORY

Biography of the Earth

Its Past, Present, and Future. By Prof. George Gamow. Revised edition. Pp. xiii+242+27 plates. (London: Macmillan and Co., Ltd., 1959.) 35*s*. net.

IN his presidential address at Cardiff to the British Association Sir George Thomson emphasized the obligation of "the popularizer to take anxious care lest in trying to simplify he make statements which are simply untrue". This book is a most unhappy example of not taking care. Prof. Gamow has a well-deserved reputation as a popularizer, and I have myself had so much entertainment and pleasure from some of his books that it was with real distress that I found in the first edition of this book (1941) so much that was misleading and irresponsible. One trivial example sent a wave of hilarity around the geological world: on p. 145 Gamow had written "the name 'Cambrian' indicates simply that the deposits of that period were first discovered and studied in Cambridge-shire (England)". In the 'revised' edition of 1959, p. 145 remains exactly the same, word for word, as before. On the same page, and the next, we still learn that "micaschists" are ordinary sandstones "metamorphized". Indeed, nearly all the pages are reproduced without change. The main alteration is in the treatment of the origin of the solar system.

Collision hypotheses are now abandoned in favour of Weizsäcker's modified version of the Kant–Laplace hypothesis. Two or three pages have been revised to include the possibility that life began with the natural synthesis of amino-acids and their eventual linking together as proteins. Piltdown man is disowned as a fake. The age of the Earth is increased from 2,000 m.y. to 5,000 m.y.; but no mention is made of the magnificent work of Claire Paterson and his co-workers; the credit all goes to the rubidium–strontium method, which we are told gives more reliable results than those based on the decay of

uranium, and has "more than doubled the estimated age of various rocks". Despite this, however, it is still stated that 1,500 m.y. "definitely represents the upper possible limit" for the age of the oceans. "Before that time all the Earth's water must have existed solely in the form of atmospheric vapour."

Corresponding to these erroneous ideas, Gamow tells us that the first extensive period of sedimentation was followed by the Laurentian revolution (about 1,000 m.y. ago). Because these layers of sediment contain but little salt, we are asked to believe "that sea water must have been quite fresh at that time". Not a word about the older orogenic belts, going back to 3,000 m.y. and beyond. Not a word about granitization, one of the most important processes affecting the Earth's biography. Seismologists will be depressed to learn that according to Gamow "the outer layer of the crust consists of a layer of granite extending to a depth of from 50 to 100 kilometres. This granite layer rests on a layer of heavier volcanic material, known as basalt, which is probably several thousand kilometres deep". Nowhere do we find a word about the Moho discontinuity or the astonishing thinness of the oceanic crust. The exploration of the ocean floors, which is becoming one of the major achievements of our time, is passed over in silence. A certain amount of continental drift is admitted, but with the proviso that it must have ceased at an early stage of our planet's history, shortly after the birth of the Moon, which stripped away the granite layer from the region that is now the Pacific basin. Not a word about palæomagnetism. Not a word about the hundreds of miles of relative movement along the San Andreas and other great faults. Not a word about the discovery that these movements have been speeding up—on average—during the last 100 m.y. or more and that we are now living in a phase of exceptionally intense geological activities. Instead, Gamow thinks "we are now living during one of the relative lulls in activity". The cause of Earth movements and mountain building is still referred to "the steady cooling and shrinking of our globe". Not a word about phase transformations and the exciting possibility that the Earth is expanding.

So one could go on. Prof. Gamow has failed to realize that the earth sciences are progressing at an ever-accelerating rate. New knowledge is continually disrupting parts of the old framework, and the geologist has to assess the bearing on his subject of the interplay of almost daily discoveries in many branches of science besides his own. Prof. Gamow has simply not taken the trouble. It is not good enough to take a pot-boiler that was thoroughly bad from the start, revise a few pages, stick on the date 1959, ignore all the unprecedented advances made since the end of the War (except for the age of the Earth) and then to claim that "the revised edition embodies the currently accepted theories", which the author believes are "now here for good". I am sorry to be so severe, but a reviewer's first loyalty must be to his subject. I know that Prof. Gamow could do very much better if he would take the necessary trouble and then re-write the book and have it examined as he goes along by a competent geologist. Perhaps he will be inspired to make amends in this way by a pregnant remark made by Igor Stravinsky in 1958: "We all feel we are right: but we felt the same way twenty years ago and today we know we weren't always right then".

ARTHUR HOLMES

ACHIEVEMENT IN THE GLASS INDUSTRY

Pilkington Brothers and the Glass Industry

By T. C. Barker. Pp. 296+20 plates. (London: George Allen and Unwin, Ltd., 1960.) 40s. net.

THE Pilkington glass enterprises began in 1826 when William Pilkington joined his brother-in-law Peter Greenall and two other men in the purchase of a small glass-works in St. Helens. This works manufactured window glass by the crown process, that is, the spinning of an opened-out bulb on the end of an iron so that a flat circular disk was formed. The disk was of uneven thickness, the centre part where it had been held on the iron being the bull's-eye sold cheaply at the time, but now sometimes made specially to provide a false appearance of antiquity. Soon William's elder brother joined him, and in 1829 the two bought out the other partners. William Pilkington's business ability was of great importance; he toured the country making contacts and obtaining orders, and the building boom of the 1830's helped the young firm to prosper. To this day the Company remains a private, family one.

The activities of the Firm have always been marked by very sound judgment in the choice of developments which were worth backing. During a depression in the industry around 1840 the improved cylinder process for sheet glass, which their rivals Chance's had been developing for some years, was introduced and the initial troubles had been overcome when the market boomed once more. Much later, in 1921 the development of the continuous process of manufacture of plate glass was undertaken in co-operation with the Ford Motor Co., and Pilkington's were ready to meet the new market which came with the expanding car industry. This fascinating story of the Ford–Pilkington co-operation is told in appendix 8. In 1919, C. W. Avery began to experiment in Detroit with a continuous process for plate glass. In 1919, he wrote: "We sent for a little crucible from Germany. It was about a month before we got the crucible back and it only held about a pint". By December 1921 1,500,000 dollars had been spent and the progress made impressed Pilkington's representatives so much that agreement was reached for co-operation in the further development of the process. Pilkington's, with their extensive knowledge of melting glass in tank furnaces, were then able to make a very important contribution. The continuous grinding and polishing plant was first put into use in 1923. In this process a continuous ribbon of glass nine feet wide issuing over a weir from a tank furnace passes through the annealing lehr and then under the grinding heads. In 1935, the twin grinder, a Pilkington development, which grinds both sides of the ribbon glass simultaneously, began operation at Doncaster.

Although there were no formal research laboratories as such until 1938, the firm was well able to make use of technical development. Cecil Pilkington was an Oxford graduate in natural sciences: in 1901, assisted by Leonard Lackland, a graduate of Liverpool, he introduced recording pyrometers and with their aid reduced the annealing schedule from 4 days to 4 hours. Electrical power was introduced in 1893: vacuum sucker pads were first used for handling plate glass in 1913. This present year, 1961, will

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uranium, and has "more than doubled the estimated age of various rocks". Despite this, however, it is still stated that 1,500 m.y. "definitely represents the upper possible limit" for the age of the oceans. "Before that time all the Earth's water must have existed solely in the form of atmospheric vapour."

Corresponding to these erroneous ideas, Gamow tells us that the first extensive period of sedimentation was followed by the Laurentian revolution (about 1,000 m.y. ago). Because these layers of sediment contain but little salt, we are asked to believe "that sea water must have been quite fresh at that time". Not a word about the older orogenic belts, going back to 3,000 m.y. and beyond. Not a word about granitization, one of the most important processes affecting the Earth's biography. Seismologists will be depressed to learn that according to Gamow "the outer layer of the crust consists of a layer of granite extending to a depth of from 50 to 100 kilometres. This granite layer rests on a layer of heavier volcanic material, known as basalt, which is probably several thousand kilometres deep". Nowhere do we find a word about the Moho discontinuity or the astonishing thinness of the oceanic crust. The exploration of the ocean floors, which is becoming one of the major achievements of our time, is passed over in silence. A certain amount of continental drift is admitted, but with the proviso that it must have ceased at an early stage of our planet's history, shortly after the birth of the Moon, which stripped away the granite layer from the region that is now the Pacific basin. Not a word about palæomagnetism. Not a word about the hundreds of miles of relative movement along the San Andreas and other great faults. Not a word about the discovery that these movements have been speeding up—on average—during the last 100 m.y. or more and that we are now living in a phase of exceptionally intense geological activities. Instead, Gamow thinks "we are now living during one of the relative lulls in activity". The cause of Earth movements and mountain building is still referred to "the steady cooling and shrinking of our globe". Not a word about phase transformations and the exciting possibility that the Earth is expanding.

So one could go on. Prof. Gamow has failed to realize that the earth sciences are progressing at an ever-accelerating rate. New knowledge is continually disrupting parts of the old framework, and the geologist has to assess the bearing on his subject of the interplay of almost daily discoveries in many branches of science besides his own. Prof. Gamow has simply not taken the trouble. It is not good enough to take a pot-boiler that was thoroughly bad from the start, revise a few pages, stick on the date 1959, ignore all the unprecedented advances made since the end of the War (except for the age of the Earth) and then to claim that "the revised edition embodies the currently accepted theories", which the author believes are "now here for good". I am sorry to be so severe, but a reviewer's first loyalty must be to his subject. I know that Prof. Gamow could do very much better if he would take the necessary trouble and then re-write the book and have it examined as he goes along by a competent geologist. Perhaps he will be inspired to make amends in this way by a pregnant remark made by Igor Stravinsky in 1958: "We all feel we are right; but we felt the same way twenty years ago and today we know we weren't always right then".

ARTHUR HOLMES

ACHIEVEMENT IN THE GLASS INDUSTRY

Pilkington Brothers and the Glass Industry

By T. C. Barker. Pp. 296+20 plates. (London: George Allen and Unwin, Ltd., 1960.) 40s. net.

THE Pilkington glass enterprises began in 1826 when William Pilkington joined his brother-in-law Peter Greenall and two other men in the purchase of a small glass-works in St. Helens. This works manufactured window glass by the crown process, that is, the spinning of an opened-out bulb on the end of an iron so that a flat circular disk was formed. The disk was of uneven thickness, the centre part where it had been held on the iron being the bull's-eye sold cheaply at the time, but now sometimes made specially to provide a false appearance of antiquity. Soon William's elder brother joined him, and in 1829 the two bought out the other partners. William Pilkington's business ability was of great importance; he toured the country making contacts and obtaining orders, and the building boom of the 1830's helped the young firm to prosper. To this day the Company remains a private, family one.

The activities of the Firm have always been marked by very sound judgment in the choice of developments which were worth backing. During a depression in the industry around 1840 the improved cylinder process for sheet glass, which their rivals Chance's had been developing for some years, was introduced and the initial troubles had been overcome when the market boomed once more. Much later, in 1921 the development of the continuous process of manufacture of plate glass was undertaken in co-operation with the Ford Motor Co., and Pilkington's were ready to meet the new market which came with the expanding car industry. This fascinating story of the Ford–Pilkington co-operation is told in appendix 8. In 1919, C. W. Avery began to experiment in Detroit with a continuous process for plate glass. In 1919, he wrote: "We sent for a little crucible from Germany. It was about a month before we got the crucible back and it only held about a pint". By December 1921 1,500,000 dollars had been spent and the progress made impressed Pilkington's representatives so much that agreement was reached for co-operation in the further development of the process. Pilkington's, with their extensive knowledge of melting glass in tank furnaces, were then able to make a very important contribution. The continuous grinding and polishing plant was first put into use in 1923. In this process a continuous ribbon of glass nine feet wide issuing over a weir from a tank furnace passes through the annealing lehr and then under the grinding heads. In 1935, the twin grinder, a Pilkington development, which grinds both sides of the ribbon glass simultaneously, began operation at Doncaster.

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that one knows he has studied them himself. It is a pity he has not made more original drawings, because some of the illustrations chosen are not very satisfactory. Dr. Randhawa, like most modern workers on the group, has little use for infra-specific categories. This is in marked contrast to the other major group of the Zygnemales, the desmids, where specialists describe innumerable varieties and forms.

Although the important work of Dr. M. B. E. Godward on the cytology of *Spirogyra* is mentioned (p. 21) it is ignored in the section on the nucleus (pp. 53–59); consequently, the taxonomic potentialities of nuclear and chromosomal structures are also ignored, as are the new species she has described. In the section on Lloyd's discovery of contractile vacuoles in the gametes of *Spirogyra*, Matvienko's finding that these may only appear in the male gamete is omitted. The maps are puzzling. Naturally, like most maps covering the distribution of freshwater algae, these show mainly where phycologists have worked, but some features are misleading. Thus there are apparently only two species of *Zygnema* and four of *Spirogyra* recorded for England, whereas, in fact, about eight times as many are recorded. It is correctly stated on p. 261 that *Zygogonium ericetorum* has been recorded from every continent, but reference to map *H* gives the false impression that it is unknown in Europe outside England, in Asia outside India and China, in Africa outside the Union of South Africa and in America outside the United States.

Such criticism of these books as seems necessary does not alter the fact that they are considerable achievements and deserve the wide circulation they are likely to obtain.

J. W. G. Lund

EUROPEAN SPIDERS

Die Tierwelt Deutschlands und der Angrenzenden Meeresteile nach ihren Merkmalen und nach ihrer Lebensweise

Begründet von Prof. Dr. Friedrich Dahl. Weitergeführt von Maria Dahl und Prof. Dr. Hans Bischoff. 47 Teil: Spinnentiere oder Arachnoidea (Araneae). XI: Micryphantidae—Zwergspinnen. Von Dr. Hermann Wiehle. Pp. xi+620. (Jena: Gustav Fischer Verlag, 1960.) 107.65 D.M.

THIS volume completes a series of monographs on the German spider fauna which began in 1926 with Dahl's *Salticidae*. The group of spiders described in this volume, known to the British araneologists as the sub-family Erigoninae, has been elevated to family rank by Dr. Wiehle under the name Micryphantidae. The text covers 615 pages, has 1,147 figures and describes 144 species in 74 genera. Together with the previous volume on the Linyphiidae, Dr. Wiehle has completed a monumental work which will stand as an authoritative text on European spiders for many years. Apart from the British Ray Society monograph by G. H. Locket and A. F. Millidge published during 1951–53, the present volume is the only modern work dealing with the difficult taxonomy of a very large family of tiny spiders, of which more than half are between 1 and 2 mm. in length. The German fauna is of particular interest to the British student because it includes both western and eastern European species, whereas the British fauna (144 species in 68 genera) is predominantly western and northern. Adequate taxonomic works on the Linyphiidae and Micryphantidae have become especially important in recent years because of the development of ecological studies on spiders, particularly those species in the litter and ground vegetation, most of which are members of these two families.

Wiehle's subdivision of the Micryphantidae into four sub-families follows closely that of Petrunkevitch in 1928. Sub-families Masoninae and Pelecopsinae have been generally recognized since they were proposed by Simon in 1884, and Wiehle has preferred Simon's name Walckenaerinae for the third sub-family instead of Petrunkevitch's Gonatiinae. The fourth sub-family, Erigoninae, remains, although there has been a redistribution of genera between it and the Walckenaerinae.

The genera and species keys owe a great deal to previous work by J. Denis in France and A. F. Millidge in England. The numerous figures are clearly drawn and an invaluable aid to identification. The list of references includes 187 titles, but omits that of Engelhardt (1958) which is referred to on page 1.

Eric Duffey

NEUROSURGERY IN WAR-TIME

Neurosurgery

Vol. 2. Edited by R. Glen Spurling and Barnes Woodhall. (Medical Department, United States Army. Surgery in World War II.) Pp. xxvi+705+12 plates (283 figures). (Washington, D.C.: Office of the Surgeon General, Department of the Army, 1959. For sale by the Superintendent of Documents, U.S. Government Printing Office.) 7 dollars.

THE previous excellent volume on neurosurgery in this series dealt with the organization of the specialty in the United States Army Medical Service during the Second World War and with head injuries; the present, and larger one, deals with spinal and peripheral nerve injuries.

The section on spinal injuries deals with every aspect of missile wounds of the spinal cord, with particular emphasis on details of nursing care, organization of evacuation and the urological problems presented by these patients. In the latter connexion, it is of interest that closed vesical drainage with manual control was preferred to automatic (tidal) drainage. An excellent account is presented of the work carried on in the paraplegic centres established in the United States to care for these terribly handicapped men, and the description of the financial and other assistance provided to resettle them in their homes and at work is impressive. The goal of those in charge of these centres is well summarized in the aphorism "Having added years to the lives of traumatic paraplegics, we must now, above all, add life to their years".

Peripheral nerve injuries are considered fully from anatomical, physiological and surgical points of view. Other chapters deal with injuries of these nerves combined with serious soft tissue, bone and vascular damage. Causalgia and its treatment are fully discussed. A most valuable chapter correlates the clinical features with the pathological changes, gross and microscopic, occurring at the site of injury in a series of more than 200 peripheral nerves.

In both this volume and that which preceded it one is constantly aware of the tremendous organizing ability which provided and so successfully staffed the large number of neurosurgical centres in the United States and abroad during the Second World War. This organization went further, however, in uniting the centres into one great team with the experience, therapeutic advances and research findings at one centre being made known to all through bulletins, meetings and the visiting consultants. The advantages of such an organization over that existing at the time in Britain need no emphasis—here, large numbers of neurosurgical (military and civilian) casualties were cared for in civilian hospitals, by neurological surgeons in some, orthopædic surgeons in others, each group working in relative isolation, some with an inadequate staff and without facilities for research or discussion of their problems with other groups interested in the field. While such a state of affairs was of course not invariable, it did exist. Not the least valuable contribution of these volumes from the United States could be the guidance they might provide concerning the organization of war-time neurosurgical services in Britain should the need for this again arise. J. E. A. O'Connell

BERYLLIUM

Beryllium

By G. E. Darwin and Dr. J. H. Buddery. (Metallurgy of the Rarer Metals, No. 7.) Pp. ix+392. (London: Butterworths Scientific Publications, 1960.) 70*s*.

POSSESSING, as it does, low density, high-elastic modulus, moderate strength and good oxidation resistance, beryllium would be an attractive structural material were it not for its low impact strength and high notch sensitivity. Because of these limitations, beryllium has been important mainly as a minor addition to alloys based on other metals, until the advent of nuclear energy made new demands on the metallurgist and necessitated a re-appraisal of the so-called rarer metals. Because beryllium has low atomic weight and very low absorption cross-section for thermal neutrons, both the metal and its oxide, beryllia, are suitable for use in reactors.

Intensive research and development work in recent years has made possible the use of beryllium for the canning of nuclear fuel elements. Much work had to be done before this stage was reached, however, and the book now under review gives a timely summary of available knowledge. All aspects of the metallurgy of beryllium are discussed including the occurrence of beryllium-bearing minerals; the extraction, production and fabrication of the metal; its physical, mechanical and chemical properties; its alloying behaviour and its nuclear properties. A chapter is devoted to beryllia, another to the "Health Hazards and Their Control" that have complicated recent work on both metal and oxide, and a useful appendix is devoted to the determination of oxygen in beryllium.

A monograph on a single metal is generally expected to refer to every relevant paper of note, and the authors have clearly borne this in mind. References are numerous throughout, frequently with just a short sentence about each paper, and there are occasions when more critical comment would have been welcome. As might be expected, this applies mainly to those parts of the book which are concerned with aspects of the subject outside the authors' personal experience. The sections more directly concerned with the production and fabrication of beryllium for nuclear energy, and with the properties of most direct relevance, are written in a much more authoritative manner, and the volume will be welcomed by all those working in this field.

If only the problem of brittleness could be overcome, beryllium would be of the greatest interest to aircraft designers. Those aeronautical engineers who are already discussing the potentialities of the metal should welcome this comprehensive treatment, and they should find the chapter on the ductility of beryllium of special interest. The book is nicely produced and well illustrated and is a useful addition to metallurgical literature. A. G. Quarrell

RARE-EARTH CHEMISTRY

The Chemistry of Yttrium and Scandium

By Dr. R. C. Vickery. (International Series of Monographs on Inorganic Chemistry, Vol. 2.) Pp. vii+123. (London and New York: Pergamon Press, 1960.) 40*s*. net.

IF the purpose of a monograph is to present the reader with a concise, critical and systematically presented résumé of knowledge in a particular field, and to spare him so far as possible the need to refer to the original literature, this book is unsuccessful. Scandium and yttrium are commonly discussed together with the lanthanons, even though in all their properties they display the behaviour expected of elements in Group IIIA of the Periodic Table. It is, in fact, impossible to consider the chemistry of yttrium, in particular, without continual comparisons with rare-earth chemistry, and, except at the level of detail and completeness found in Gmelin's *Handbuch*, it is debatable whether the elements justify a book to themselves.

Following a rather diffuse discussion of the history, natural occurrence and atomic properties of both elements, the author sets out to treat the isolation and the chemistry of each in turn. In matters that touch on Dr. Vickery's extensive practical experience of rare-earth chemistry—the (curiously old-fashioned) treatment of their minerals, the extraction and the analytical chemistry of scandium and yttrium—the reader is overwhelmed with facts and details of procedure. Other chapters that should clearly set out the chemical and physical properties, crystal structures and thermodynamic data for their compounds are sketchy, confusing in arrangement and, in parts, apparently ill digested. Plates, diagrams and textual statements are too often quite uninformative, and the whole lacks a certain coherence. Much of it might have been written thirty years ago, and even such separation procedures as ion exchange receive a disproportionately small allowance of space. On the credit side the author has assembled a considerable (but not a complete) bibliography, though the reader's confidence in the reliability of references may be shaken by other evidence of exceptionally careless proof-reading and preparation of the manuscript. Counting obvious typographic errors, mis-spelt names, omission of units and downright factual blunders, I noted corrections on at least 29 of the 116 pages of text. A purist would want to alter the lamentable English style on many more. The book has a limited usefulness. J. S. Anderson

Haldane of Cloan

His Life and Times, 1856–1928. By Dudley Sommer. Pp. 448+12 plates. (London: George Allen and Unwin, Ltd., 1960.) 42*s.* net.

IN writing this new life of Lord Haldane, Mr. Sommer had access to much material not available to Sir Frederick Maurice; but though his book gives a vivid and well-balanced picture of Haldane it does no more than General Maurice's book to solve the enigma of Haldane, and throws scarcely any fresh light on his achievements, particularly in those fields of most interest to the scientist. Of Haldane as an administrator, an educationist or a philosopher we are shown, in fact, less rather than more: the *Machinery of Government* report is dismissed all too briefly, and the reader of Mr. Somner's book is given no indication of the extent to which Haldane's thought has influenced subsequent investigations into the organization of government. The new material has gone rather to expand the political picture of the times in which Haldane moved, and of his later years particularly we are told singularly little.

Mr. Somner frankly acknowledges his debt to General Maurice, but the whole structure of his book is on different lines, without, however, contributing anything fresh, except perhaps new light on particular episodes or the general political background. Much of Haldane's thought, not only in administration but also in education, and more especially university education, and on the organization of research, for example, is, however, remarkably relevant to the issues of to-day, and what one would have looked for in any new life of Haldane on this scale is some reassessment of the significance of his thought and work in such fields. No hint is given, however, of Haldane's part in stimulating the institution of the University Grants Committee, or of the research grants of the Department of Scientific and Industrial Research, although his work for adult education is recognized. To the scientist who has any knowledge of Haldane's work or thought in such fields it may well seem that an invaluable opportunity has been missed of re-examining critically Haldane's work and thought as a strategist, as an educationist, as an administrator or as a philosopher in a context which is as relevant to the issues of to-day as a generation ago. It is in such a context, moreover, that the stature and achievements of such a man as Haldane are most apparent. R. Brightman

Trans-Antarctic Expedition, 1955–1958

Scientific Reports. No. 4: Tides at Shackleton, Weddell Sea. By J. G. D. Pratt. Pp. 21+2 plates. (London: Trans-Antarctic Expedition Committee, 22, Gayfere Street, S.W.1, 1960.) 12*s.* 6*d.*

A BRITISH contribution to tidal knowledge in the Antarctic is always an event, and *Tides at Shackleton* is no exception. Piquancy is added to the article not only by the comparatively unusual method of observation—by Worden gravimeter on a freely floating ice shelf—but also by the refreshing and often humorous method of presentation. The ingenuity required to improvize and maintain such a sensitive instrument under the physical conditions encountered, so as to obtain a sufficiently long series of observations for analysis, is greatly to be admired, as also is the painstakingly careful treatment of the data. After having analysed these data by standard methods of tidal analysis, and obtained results of which any tidologist would be proud, the author then proceeds to devise what he calls a 'least squares' method of analysis (all standard methods of tidal analysis are fundamentally based on least squares theory) and produce harmonic tidal constants seriously in discord with the 'standard' results. Pratt gives his reasons for this as being the existence of spurious oscillation with periods near 24 hr. and 40 hr. But while a spurious diurnal oscillation can seriously affect the diurnal constants in a tidal analysis, neither this nor the 40-hr. oscillation could affect the phase-lag of M_2 by 75°. Rather than force what are believed to be transient oscillations into the mould of harmonic constituents by a least-squares method, it would be better to examine the residuals obtained after subtracting a predicted tide (from the results of tidal analysis) from observations. There must be an error in the 'least squares' analysis for M_2 (and probably also for O_1), and, in view of the paucity of tidal data in the Weddell Sea and Mr. Pratt's own sterling efforts, this should be exposed.

J. R. Rossiter

Industrial Fatty Acids and Their Applications

Edited by E. Scott Pattison. Pp. vi+230. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1959.) 56*s.* net.

THIS book is edited by Mr. E. Scott Pattison, manager of the Fatty Acids Producers' Council, New York, and consists of a series of contributions by senior consultants of a number of major chemical firms in the United States on the industrial production and main usages of the varied chemical derivatives of fatty acids.

Some of these products have an annual commercial utilization of many millions of pounds; their value as detergents, plasticizers, food additives, cosmetics, etc., are clearly and concisely described. Special mention is made of the recent increased commercial interest in 'tall oil', a rosin/fatty-acid by-product of the paper-making industries. The purification, chemical nature and usages of derived fatty acids are given extensive treatment in the text, as also are the industrial processes involved.

The interactions of fatty acids with varied chemical reagents are given detailed treatment and chemical equations are employed extensively to illustrate the fundamental reactions occurring.

This book will prove of great interest to the chemists and chemical engineers who wish to keep abreast of modern development in the industrial field of fatty-acid technology. It should also prove of absorbing interest to the academic organic chemist.

D. T. Lewis

Space Research

Proceedings of the First International Space Science Symposium, Nice, January 11-16, 1960. Edited by Dr. Hilde Kallmann Bijl. Pp. xvi+1195. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1960.) 170*s.*

THE First International Space Science Symposium was held at Nice in January 1960, under the auspices of the Committee on Space Research. The volume under review thus has a historic character as well as being an exceptionally well-edited proceedings of the symposium printed and bound to the same high standard.

An account of the symposium was given in *Nature* on June 4, 1960, so no more than the section headings

will be given here: (1) "The Earth's Atmosphere", (2) "The Ionosphere", (3) "Tracking and Telemetering", (4) "Solar Radiation", (5) "Cosmic Radiation", (6) "Interplanetary Dust", (7) "The Moon and the Planets". Radiation from celestial sources is included under "Solar Radiation". The 100 papers cover mostly the two years of space research from the launching of the first artificial satellite to the time of the conference. Since another symposium is planned by the committee for next spring, there can be little doubt that this volume is just the beginning of an important series, and it is to be hoped that the future conferences and their proceedings will enjoy the same success as the first.

R. L. F. Boyd

Health Physics in Nuclear Installations

Symposium organised at the Danish Atomic Energy Centre, Risø, 25–28 May, 1959. Pp. 410. (Paris: Organization for European Economic Co-operation, European Nuclear Energy Agency: London: H.M. Stationery Office, 1959.) 2,500 francs: 37*s*. 6*d*.; 6 dollars; 21.30 D.M.

THIS volume contains thirty-two papers delivered at a conference on health physics in nuclear installations, held at Risø, near Copenhagen, in May 1959, under the auspices of the Organization for European Economic Co-operation and the Danish Atomic Energy Commission. The purpose of the conference was partly to introduce the subject to those entering this field, and partly to permit the presentation and discussion of new results. Accordingly there are several introductory papers on such subjects as the biological effects of ionizing radiations, the basis of the maximum permissible levels of exposure, and measuring techniques.

These are followed by papers on the control of radiation-levels and of the contamination of personnel. Practical problems of health physics and criticality control in specific types of installation, including reactors, chemical plant, and high-energy accelerators, are discussed. There is a final section on emergency situations.

All the papers are by acknowledged experts from the United States, Great Britain and Europe, and are authoritative and well produced. This is a valuable record for those who attended the conference. However, for those new to the subject, it does not quite take the place of a well-organized text-book, and, since practically all the information it contains can be found in the technical literature, it is of limited use to experts. The volume will probably be a useful addition to many libraries.

W. J. Whitehouse

Absorption Spectra in the Ultraviolet and Visible Region

Edited by Dr. L. Lang, in collaboration with Dr. J. Szöke, Dr. G. Varsányi and M. Vizesy. Vol. 1: Pp. 414. Vol. 2: A Theoretical and Technical Introduction. Pp. 80. (Budapest: Publishing House of the Hungarian Academy of Sciences; London: Collet's Holdings, Ltd., 1959.) 137*s*. 6*d*.

THESE are the first two volumes of a series in which "subsequent volumes will contain spectra of foreign authors and the collection will thus emerge from its strictly national environment and assume an international character". Volume 1 includes the spectra of some two hundred assorted substances, mostly in solution, in the form of graphs of log ε against wave-length supplemented with tables of selected values of log I/I_0 at different wave-lengths for specified concentrations. The volume contains separate substance and formula indexes, but no attempt has been made at classification. It is impossible briefly to indicate the nature of the substances considered—which range from complex compounds of cobalt through substituted benzenes to phenanthrenes, flavones and xanthins. These are presented in loose-leaf: unhappily, the file containing the sheets of the review copy was not strong enough for its job.

Volume 2 consists of a "theoretical and technical" introduction. The text is some forty pages long. It will scarcely help those who know some spectroscopy already, and it is, naturally, too condensed to be of much value as an introduction. It is written in English which is nearly always intelligible but often odd. The discussion of the emission from a hydrogen lamp is not only odd but also incorrect.

The preparation of a reference set of ultra-violet spectra presents an enormous task, in which the first step is to adopt a practical classification. It is indeed useful to have the Hungarian results collected together, but this random sample seems unlikely to serve as a basis for the ultimate catalogue of these spectra.

R. F. Barrow

An Introduction to Industrial Mycology

By George Smith. Fifth edition. Pp. xvi+399. (London: Edward Arnold (Publishers), Ltd., 1960.) 40*s*. net.

THE publication in 1938 of *An Introduction to Industrial Mycology* by Mr. George Smith was a marked contribution to the study of moulds. That the book has now reached its fifth edition is evidence of how well it has been received. The text of the fifth edition includes descriptions of a few genera and species of fungi which were not previously included, and the relevant literature of systematic mycology which has appeared since the publication of the fourth edition in 1954 has been considered.

The major portion of the book is devoted to descriptions and illustrations of most genera of moulds which regularly occur on industrial products. This section is of considerable value to students of general mycology especially because of the attention devoted to members of the Fungi Imperfecti and particularly to species of *Penicillium* and *Aspergillus*. The remainder of the book provides a most useful introduction to beginners in mycology, since it deals with laboratory equipment and techniques including microscopy and photomicrography. Mr. Smith is to be congratulated on presenting the subject-matter in a most readable form with complicated terminology reduced to a minimum. One of the delightful features of the text is the manner in which the author draws on his rich store of experience and gives practical advice on techniques and staining which is invaluable to newcomers in the field.

Almost all the illustrations are from original photomicrographs and, being of high quality, add greatly to the value of the book. As compared with the previous edition, one figure has now been omitted; but replacements of four plates and new illustrations of eight species are included. The publishers have maintained the high standard shown by the previous edition.

John Colhoun

NATURALLY OCCURRING ALPHA-ACTIVITY OF DRINKING WATERS

By R. C. TURNER, J. M. RADLEY and Prof. W. V. MAYNEORD
Physics Department, Institute of Cancer Research : Royal Cancer Hospital, London, S.W.3

THE present article represents a continuation of investigations into the nature and levels of naturally occurring α-activity in man and his environment. We have demonstrated the great variations of α-activity to be found as between different human foods[1]. Following the observations on foods it was natural to study the radioactivity of drinking waters supplied to the population of Great Britain.

Several investigators[2-6] have reported measurements of the radium-226 content of potable waters in other countries, but very few data have been published during recent years on the activity of waters in Britain. Following the observations of J. J. Thomson[2] early in this century on Cambridge water, there was considerable interest in this subject, but much of the earlier work leaves doubt as to whether the observed values applied to radium-226 or also included gaseous products such as radon-222, known to exist in certain waters at considerably higher levels of activity than its parent. In the present experiments we have measured the radium-226 content of 71 drinking waters available in Britain, and in addition we report the values for radon-222 and radium-224 (thorium *X*) when present.

In most instances the water samples have been made available to us by the co-operation of the local water undertakings at the request of the Ministry of Housing and Local Government

Experimental Procedure

The water samples were selected from several points of view, including the size of population supplied and the nature of the associated geological formations. The specimens were chosen with the view of assessing the total daily intake of natural radioactivity throughout Britain from its water supplies.

Preliminary experiments indicated that, if polythene containers were used for the collection and transport of the samples, it was unnecessary to add either carrier or acid agent to the water at the time of sampling. No residual α-activity could be detected on the walls of such containers even after they had housed specimens of relatively high activity for several days.

A litre of each specimen of water to be measured was evaporated to dryness in a 'Vitreosil' beaker and the α-activity of the residue measured, using the α-ray counting technique previously described[10]. In a few cases where the mineral content of the water was very low, 20 mgm. of barium chloride having known low α-activity was added to the water before evaporation in order to provide adequate residue.

Measurements were made on each specimen of residue immediately after evaporation and at intervals of a few days during the following 30 days, by which time the radon-222 and its α-emitting daughters polonium-218 (radium *A*) and polonium-214 (radium *C'*) would have reached equilibrium with the radium-226 present. After 30 days no further change of α-activity of the residue could be detected in any of the specimens. Assessment of the amount of radon-222 above the level required for equilibrium with the radium-226 present in each water was effected by observations on a liquid sample 2–3 mm. deep, sealed in contact with a zinc–cadmium sulphide phosphor of area 93 cm.^{2}. Adsorption by zinc sulphide crystals of the daughter products of radon-222 present in solution had been previously reported by Rosholt[11], who used the method to obtain quantitative yields of lead-218 (radium *B*) and polonium-214 (radium *C'*).

It has been observed by us that, when water containing dissolved radon at a level of activity many times higher than its content of radium-226 is assembled in such an arrangement, the α-counting-rate increases for the first hour after sealing the sample and thereafter decreases with the half-life of radon-222 (3·8 days), until the activity has fallen to the level represented by the content of radium-226 and other long-lived activity. If at any intermediate stage the water is removed and the activity of the phosphor itself observed, the counting-rate decreases rapidly during the first 10 min. or so, corresponding to decay of polonium-218 (radium *A*), and thereafter falls with a half-life of approximately 40 min. compatible with the decay of lead-214 (radium *B*) and bismuth-214 (radium *C*). It is thought that the solid decay products of the dissolved radon are deposited on the surface of the zinc sulphide crystals and the α-particles emitted by polonium-218 (radium *A*) and polonium-214 (radium *C'*) are assumed counted with 2π efficiency. So long as the water itself is present, the observed activity is maintained with the half-life characteristic of radon, although the radon α-particles themselves may contribute little to the counting-rate since their range in the medium is only 1 or 2 per cent of the depth of the water layer.

Fig. 1 shows the characteristic pattern of decay of α-activity observed in a water sample containing radon greatly in excess of the amount required for equilibrium with its radium-226 content. Each estimate of radon content has been corrected for decay between the time of collection of the sample and the actual measurement.

In a number of the more active water residues, fast pairs of α-particles were observed, indicating the presence of at least the shorter-lived members of the thorium series[10]. This conclusion was borne out by the subsequent variation of the thorium series activity with time, since it decreased rapidly during the first 20 days or so following evaporation, after which the thorium activity remained constant at a relatively low level. The presence of radium-224 (thorium *X*) in American potable waters has already been reported by Stehney[2], who found the levels of radium-224 in freshly sampled waters comparable with those observed for radium-226. Due to the short half-life of radium-224 (3·64 days) and of its α-emitting daughter members of the thorium series, this α-activity decreases to very low values in the 2–3 weeks subsequent to sampling. There is little doubt that the decreasing thorium series activity observed

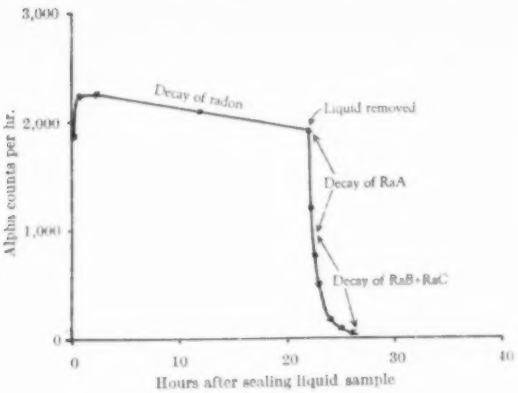

Fig. 1

in a number of our specimens is due to the presence of radium-224 and its daughters in the freshly sampled waters. In the absence of long-lived members of the thorium series, such as thorium-228 (radiothorium-228), at comparable levels of activity, the initial thorium series activity of these waters is regarded as due to radium-224 and its daughters. These values are given in Table 3 corrected for decay of activity since time of sampling.

In a number of the waters having very low activity it has not been possible to determine either the level of radium-224 or of the long-lived members of the thorium series.

In a few specimens having intermediate values of long-lived α-activity, the presence of thorium-228 and its daughters has been observed but at levels representing small fractions of the total long-lived α-activities given in Table 1.

Results

The values of long-lived α-activity together with the activities due to excess radon-222 and its daughters are given in Table 1 for various categories of water.

In a number of instances waters from more than one source have been measured for a given town, and these are listed separately. Ground-waters have been divided into two groups comprising those derived from boreholes in chalk and those from boreholes in other geological strata. Surface waters include sources such as springs, rivers, lakes and reservoirs.

Column 4 of Table 1 gives the content of solid matter observed (in parts per million), and column 5 the long-lived α-activity of this residue 30 days after evaporation of the liquid specimen.

Table 2 indicates the range of values and mean long-lived α-activity for the different categories of water and their residues.

In Table 3 the total α-activity of a number of the more active samples is broken down into its three main components.

Discussion

It will be seen from Tables 1 and 2 that the highest values of long-lived α-activity are found in the group of spa waters, which possess high contents of mineral matter having specific activities greater than those

Table 1

Origin	Long-lived α-activity (μμc./litre at 30 days)	Excess radon and daughters (μμc./litre at time of sampling)	Solid matter observed (parts per million)	α-Activity of residue (μμc./gm. at 30 days)
Spas				
*Vichy Celestin	48·5	—	3,150	15·4
Juventus	45·5	—	1,250	36·4
*Vichy Catalan	43·3	—	1,700	25·5
Bath	37·0	1,000–2,000	2,540	14·7
Llandrindod	26·2	200–300	3,320	7·9
Leamington	16·7	200–300	10,200	1·7
Buxton	4·5	1,500–2,000	210	21·5
*Vittel	2·2	—	675	3·3
*Perrier	1·8	—	370	4·8
Cornish waters				
St. Ives 1	9·40	9,000–10,000	163	57·6
Helston 3	4·10	600	170	24·1
Helston 2	2·20	100–200	125	17·6
Helston 1	1·41	1,000–2,000	83	17·0
Penzance 2	1·24	700–800	54	23·0
Penzance 1	1·02	100–200	70	14·6
St. Ives 2	1·00	9,000–10,000	42	23·8
Penzance 3	0·90	500–600	133	6·8
Camborne 1	0·59	4,000–5,000	83	7·1
Camborne 2	0·46	4,000–5,000	5	92·0
Ground-waters (not chalk strata)				
Bristol 1	2·90	300–400	1,230	2·4
Wolverhampton	2·28	—	273	8·4
Bristol 2	1·75	600–700	300	5·8
Leamington	1·60	100–200	420	3·8
Spalding	1·34	100–200	360	3·7
Hartlepools	1·00	100–200	380	2·6
Ashford (Kent) 2	0·58	~ 10	210	2·8
Cirencester	0·38	—	290	1·3
South Staffs 1	0·37	—	133	2·8
Ground-waters (chalk strata)				
London 1	1·22	—	380	3·2
Uxbridge	0·65	—	216	3·0
Canterbury	0·30	—	234	1·3
Sutton (Surrey)	0·27	10–20	100	2·7
Ashford (Kent) 1	0·26	—	200	1·3
Portsmouth	0·23	—	209	1·1
Colne Valley	0·22	100–200	360	0·6
Amersham	0·22	—	217	1·0
Barnet	0·19	100–200	200	1·0
Farnham Common	0·11	—	125	0·9
Brighton	0·11	—	188	0·6
Surface waters				
Bristol 3	0·81	100–200	370	2·2
Glamorgan 1	0·62	300–400	240	2·6
Bristol 4	0·52	50–100	158	3·3
London 3	0·47	—	380	1·2
London 2	0·41	—	284	1·5
Bath	0·33	10–20	244	1·4
Belfast	0·38	—	30	13·1
Paignton	0·30	—	25	12·0
Blaenau Festiniog	0·20	—	—	—
Skipton	0·20	< 1	80	2·5
Aberdeen	0·14	—	42	3·3
Manchester 1	0·12	—	54	2·2
Charminster	0·11	—	96	1·2
Dundee	0·11	< 1	33	3·3
Torquay	0·11	< 1	55	2·0
Edinburgh	0·10	< 1	33	3·0
Aberystwyth	0·10	—	—	—
Glasgow	0·09	—	—	—
Glamorgan 2	0·09	—	33	2·7
Sheffield	0·09	—	54	1·7
South Staffs 2	0·08	—	208	0·4
Hamilton	0·08	< 1	38	2·1
Birmingham	0·07	—	33	2·1
Manchester 2	0·05	—	29	1·7
Argyll	0·05	< 1	15	3·3
Elan Valley	0·04	—	5	8·0
Caernarvon	0·04	—	—	—
Manchester 3	0·04	—	21	1·9
Dolgelley	0·03	—	30	1·0
Bangor	0·03	—	—	—
Betws-y-Coed	0·03	—	—	—
Hazleton	0·02	—	—	—

* Bottled specimens as purchased

Table 2. Long-lived α-Activities in Drinking Waters and in their Residues

Type of water	No. of samples	Activity of water in μμc./litre			Activity of residue in μμc./gm.		
		max.	min.	mean	max.	min.	mean
Spa	9	48·5	1·8	25·1	36·4	1·7	14·6
Cornish	10	9·4	0·46	2·2	92·0	6·8	28·4
Borehole (not chalk)	9	2·9	0·37	1·4	8·4	1·3	3·7
Borehole (in chalk)	11	1·2	0·11	0·34	3·2	0·6	1·5
Surface	32	0·8	0·02	0·18	13·1	0·4	3·2

Table 3. α-Activities in μμc./litre

Specimen		Short-lived α-activity due to radium-224 (Th *X*) and daughters at time of sampling	Long-lived α-activity after 30 days	α-Activity due to radon-222 and daughters at time of sampling
Llandrindod Spa		30·0	26·2	200–300
St. Ives	1	21·0	9·4	9,000–10,000
Bath Spa		7·7	37·0	1,000–2,000
Bristol	2	2·9	1·8	600–700
Helston	2	2·8	2·2	100–200
Helston	3	2·4	4·1	~ 600
St. Ives	2	0·7	1·0	9,000–10,000
Penzance	3	0·5	0·9	500–600
Camborne	1	0·3	0·6	4,000–5,000
Penzance	1	0·3	1·0	100–200
Camborne	2	0·2	0·5	4,000–5,000

found for surface waters or waters derived from boreholes.

The Cornish specimens, although having a mean level of activity lower than the spa waters by a factor of 12, are still approximately ten times higher in activity than the mean values of chalk borehole or surface waters. The mineral contents of the Cornish waters are relatively low; but the mineral matter has specific activities ranging up to 92 μμc./gm., doubtless associated with the known deposits of uranium and radium in parts of that county.

Next in descending order of long-lived α-activity come the drinking waters derived from boreholes in geological strata other than chalk. The mean activity of this group is only slightly lower than that found for the Cornish waters, and this would appear to be due to their higher mean contents of mineral matter, 400 parts per million compared with 90 for the Cornish samples.

Waters derived from boreholes in chalk have still lower activities with a mean level down by a factor of 4 below those derived from boreholes in other strata. It is interesting to note that the mean value found for the α-activities of their mineral residues (1·5 μμc./gm.) is very close to that reported previously by us[12] for the α-activity of chalk specimens.

The least-active group of waters observed by us are surface waters from rivers, lakes and reservoirs, even though a number are derived from areas of Pre-Cambrian or granitic rock formations. Their mean mineral content is 100 parts per million and their mean long-lived α-activity is lower by a factor of 12 than the Cornish waters.

There was, of course, the possibility that a substantial fraction of the observed long-lived α-activity was due to uranium-238. However, measurements of uranium contents of a number of waters in Great Britain have been reported by Smith and Chandler[13], who found values of less than 1 μgm. (0·34 μμc.) per litre in 124 out of a total of 162 specimens examined. Waters with values higher than this figure were, with one exception, not drinking waters. Our own observations on the growth of α-activity of the residues during the 30 days following evaporation leave little doubt that also in our series of waters the content of radium-226 is several times higher than the activity due to uranium-238.

Moreover, investigations of the uranium contents of North American river waters by Rona and Urry[14] show a ratio of radium-226 to uranium-238 of approximately 4 : 1. In another study of the activities of ground waters in the United States, Scott and Barker[15] also observed levels of radium-226 in excess of those due to uranium-238.

These results are borne out by the chemical estimations made by us of the uranium-238 contents of a number of our more active residues. These confirm the presence of uranium at levels of activity which represent only a small fraction of the total long-lived α-activity in each case. It is to be noted that even if the radium/uranium ratio is as low as 4 : 1, then the α-activity due to radium-226 and its daughters will still comprise 90 per cent of the total long-lived activity contributed by members of the uranium series.

In respect of the thorium series, Stehney[2] found no evidence of long-lived members such as thorium-228 in his studies of American potable waters, while Rona and Urry[14] assessed the ratio of thorium-230 (ionium-230) to uranium-238 in North American river waters as being a very small fraction of unity. The very low levels of long-lived α-activity due to the thorium series found by us in the present investigation agree with the findings of these observers.

In the absence, therefore, of either uranium-238 or thorium-228 at levels of activity comparable with those due to radium-226, the long-lived α-activities listed in Table 1 may be regarded as due to radium-226 and its α-emitting daughters, radon-222, polonium-218 and polonium-214, existing in radioactive equilibrium. The radium-226 content of any particular specimen is therefore taken as one quarter of the long-lived activity given in column 2 of Table 1. It will be seen, therefore, that the contents of radium-226 observed in this series of waters cover a range of 2,400-1, namely, from 0·005 μμc./litre to 12·1 μμc./litre.

If we exclude the spa waters and assume a daily intake of 2·5 litres per head of the population of Britain[16], then the daily intakes of radium-226 from water alone cover a range of almost 500-1, namely, from 0·013 μμc. to 5·9 μμc. In terms of long-lived α-activity the intakes from water range from 0·05 to approximately 24 μμc. per head per day.

So far we have considered only the long-lived α-activity due to the presence of radium-226 and its daughters. It will, however, be seen from Table 1 that a number of the waters possess relatively very high contents of radon-222 and its daughters at the time of sampling. This is especially the case in the Cornish specimens where the α-activities due to radon-222 and its daughters, polonium-218 and polonium-214, range up to 10,000 μμc./litre. On the basis of a daily intake of 2·5 litres the ingested α-activity can therefore be as high as 25,000 μμc. a day, that is, approximately 8,000 μμc. of radon and of each of its two short-lived α-emitting daughters. In any attempt to assess the possible significance of these materials we are faced with an almost complete lack of data concerning their metabolism in the human body. Meyer[17] in a classical series of experiments in the late 1920's came to the conclusion that

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radon ingested in drinking water had a 'mean life' of about 1 hr. in the body, being excreted principally by the lungs. On this assumption it is easy to calculate that during its stay in the body approximately 0·75 per cent, that is, 60 $\mu\mu$c. of radon and of each of its two α-emitting daughters, disintegrate completely. Since 1 $\mu\mu$c. of radon-222 comprises $1{\cdot}78 \times 10^3$ atoms of radon, this implies the production of about 3 million α-particles and of a million or so atoms of lead-210 (radium *D*) in the body as the result of each day's intake of such water. In a future paper it is hoped to discuss certain aspects of the radiation dosimetry resulting from these findings.

It will be seen from Table 3 that a number of waters at the time of sampling also contain radium-224 (thorium *X*) and its three α-emitting daughters at levels of activity comparable with those of the long-lived activity due to radium-226 and its daughters. Since radium-224 is an isotope of radium-226 their fundamental chemistry would be identical, but the short mean life of radium-224 and its decay products may result in a very different distribution of absorbed energy.

Daily Intakes of Alpha-Activity

We now consider the mean daily intakes of α-activity per head of population resulting from drinking water. From information kindly supplied by the Ministry of Housing and Local Government we have estimated the number of consumers of each of the principal water supplies. Assuming a daily intake of 2·5 litres per head the mean daily intakes of α-activity from this source for various sections of the population are estimated in Table 4.

Table 4. Mean Daily Intake of α-Activity from Drinking Water $\mu\mu$c. per Head of Population

Group of population	Long-lived activity Ra-226 and daughters	+ Activity radon and daughters	+ Activity Ra-224 and daughters
Cornwall	4·5	8,300	~ 5·5
London area	1·0	20	very small
Whole of Britain	0·5	17	" "
Scotland	0·25	2	" "
Spa patients (1 litre per day)	21·1	~ 1,000	—

It will be seen that the mean daily intakes of long-lived α-activity for the four groups cover a range of 18 to 1, whereas from Table 1 it is clear that the range of individual intakes may exceed 400 to 1. For the mean daily intakes of radon plus daughters we have a range of 4,000 to 1 between the groups, with the range for individuals exceeding 10,000 to 1. The low mean value of long-lived α-activity in the Scottish waters illustrates, rather surprisingly, the low values which may be encountered in areas of granitic formations. For comparison, Table 4 also shows the approximate daily intake of α-activity resulting from the consumption of 1 litre per day of British spa water having an activity equal to the mean value observed by us for this type of water.

Maximum Permissible Levels of Natural Activity

The report of the International Commission on Radiological Protection[18] deliberately excludes 'natural background' from its scope. It is, however, recommended by the International Commission that, in considering the exposure of large populations in relation to somatic effects, the maximum permissible level be taken as one thirtieth of the continuous occupational value (168 hr./week) computed according to its basic rules. The value of maximum permissible concentration for soluble radium-226 in water suggested by the International Commission for continuous occupational exposure is 100 $\mu\mu$c./litre, so that the value for large populations would be 3·3 $\mu\mu$c./litre. This value is lower than our observed values for British spa waters and two Cornish waters. The activities of several other waters are more than 10 per cent of this estimate. A similar situation has been noted for some large populations in the United States[19].

However, direct observations by us[16] on human skeletons from Cornwall show that the radioactivity observed in them is many times less than would be expected on the basis of the assumptions made by the International Commission. The observed mean level of activity of the skeletons is a factor of at least a thousand below the lowest body burden known to have resulted in a tumour.

The apparent anomaly arises largely because the biological parameters which have been used in the calculations were based on observations on human subjects having large radium burdens acquired many years previously and who were therefore excreting the radioactive material at a very low rate.

In a previous article[20] we reported investigations of the levels of natural α-activity present in the daily diets of the population of Great Britain and came to the conclusion that the daily intakes of such activity could vary from a minimum of 4 or 5 $\mu\mu$c. to 400 or 500 $\mu\mu$c. or even more, depending on the particular choice of diet. It is evident that in places where the drinking water has a level of α-activity at the higher end of our observed range and the individual intake from food happens to be at the lower end of the range of dietary activity, then the daily intake of natural α-activity will be dominated by the contribution from water. In other locations where the drinking water is derived from surface sources having much lower activity, the contribution from food will be predominant, regardless of the choice of diet.

Whether the human body finds it easier to retain radium-226 and its daughters present in soluble form in drinking water than to retain the same elements, possibly in different chemical form, ingested in food, is not yet known. The relative contributions made by water and food to the real retention and utilization by the body of α-active substances and the factors which control retention in the two cases are the subject of present investigations.

Comparison with Fission Product Activity in Waters

Finally, perhaps we may consider these daily intakes of natural α-activity in water in relation to the published figures of the artificial β- and γ-activity due to the presence of strontium-90 and cæsium-137 in drinking water in Great Britain[21].

The pattern of distribution of these fission products is quite different from that of the natural α-activity, since they appear at their highest levels in surface waters. Ground waters have extremely low contents of fission products, but, as we have seen, high values of natural α-activity.

From the latest figures available (for the first half of 1959) we calculate the mean contents of strontium-90 and cæsium-137 in surface waters as 0·75 μμc./litre and 0·20 μμc./litre, respectively. The mean daily intakes of populations ingesting such drinking waters would therefore be 1·9 μμc. and 0·5 μμc. of the two nuclides, respectively.

For large populations the International Commission on Radiological Protection suggests 33 μμc./litre and 6,000 μμc./litre in water, respectively, for these materials as the maximum permissible concentrations. It will be seen that the observed values are very small in comparison to these permissible levels.

Note added in proof. Since these investigations were completed, we have had the opportunity of examining specimens of drinking waters supplied to Horrabridge, Devon. The radioactivity of these particular waters has been the subject of recent communications[22,23] concerning the incidence of cancer in the area. We find the long-lived natural activity of the Sampford Spiney supply to be 0·6 μμc./litre, and its content of radon + daughters 2,500–5,000 μμc./litre. It will be seen that these values are well within the range reported in Table 1 above for waters in south-west England.

Many of the water samples were obtained through the goodwill and co-operation of Mr. A. W. Kenny, of the Ministry of Housing and Local Government, who kindly approached on our behalf the chief engineers of numerous water undertakings, to all of whom we would like to express our sincere thanks.

Our thanks are also due to Mr. J. Crookall, of this Department, for chemical estimations carried out on a number of the samples.

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FIRE RESEARCH*

By S. H. CLARKE, C.B.E.

THE continuous systematic study of fire protection started in Europe and the United States in the closing years of the last century. Added impetus came with the Second World War, and modern fire research owes much to the vision of the late Sir Reginald Stradling, chief scientific adviser to the Ministry of Home Security, to Lord Falmouth, head of the Fire Research Division, and to the knowledge and experience of Prof. G. I. Finch and Dr. D. T. A. Townend. Prof. Finch suggested critical experiments which were of great value in elucidating some of the more important phenomena. He showed that, although many of the problems of fire protection were extremely intricate, they were in fact the result of a pattern built on relatively simple principles.

For a fire to occur there must be fuel, oxygen, and a source of ignition; there are exceptions, but they are of almost negligible practical importance.

It is helpful to approach the study of fire by examining a shallow dish of petrol—a volatile, flammable liquid. If a small flame is gradually brought near the surface the vapour ignites when the flame is perhaps an inch from the liquid; the eye can just follow the rapid spread of flame. Incidentally, a cigarette can be extinguished by gently dipping the lighted end into a tray of petrol.

If the experiment is repeated with a tray of a less volatile liquid, say paraffin (kerosene), it will be found that quite a large flame must be played directly on the surface for a short time before ignition takes place. Once ignition occurs, however, and the liquid is warm, if the flames are snuffed out by placing a board over the tray, immediate re-ignition occurs when a fresh flame approaches the surface, exactly as with petrol.

It is thus necessary to distinguish two temperatures; first, the 'flash-point', which is the temperature at which vapour distils rapidly enough to support a flame; and, secondly, the 'ignition temperature'—and this is usually a higher one—at which the flammable vapours can be ignited.

Although the chemical processes that are involved when wood is burned are much more complicated, in some ways wood and other similar materials may be thought of as behaving like liquids with a high flash-point. When wood is heated, it decomposes, and gases and vapours are formed which, in contact with air, behave just like those of petrol or paraffin, and burn with flame.

G. I. Finch summarized very neatly the behaviour of wood as a fuel. He found it convenient to classify combustible materials in three grades which he called "tinder", "kindling" and "bulk fuel". Tinder can be ignited by an ordinary match and is then able to continue burning; it has a specific surface of not less than 20 cm.²/gm.; paper or wood shavings are an example. Kindling cannot be ignited by a match but can by tinder, and, if it is suitably arranged, can continue to burn; it has a specific surface of not less than 2 cm.²/gm. Bulk fuel can only be ignited by a

* Substance of a discourse at the Royal Institution on October 21.

Fig. 1. Successive stages in the ignition of wood by radiation. Pictures taken at about 0·01 sec. exposure. Note ignition occurs above the specimen outside the radiation field. By courtesy of the Director of the Fire Research Station. Crown copyright reserved

fire which already involves kindling, but under suitable conditions it can sustain self-combustion; its specific surface is less than 2 cm.²/gm.

P. H. Thomas and D. L. Simms observed an interesting feature in the burning of wood. When small specimens are subjected to radiant heat of high intensity, vapours and gases are emitted which ignite spontaneously. The interesting thing is that ignition occurs not at the point of applied heat but some distance above, and the flame jumps back rapidly to the wood (Fig. 1).

It should be noted that it is inaccurate to speak of a liquid burning; combustion occurs in the vapour phase, and in a region where there are convenient proportions of vapour and oxygen. When wood burns, about half the mass is consumed as flame and about half glows as charcoal.

The processes described form the background to the early stages of most fires. Once started, a fire spreads until all the exposed surface of combustible material is involved in flame. At that moment the maximum temperature is reached. The rate at which it is reached depends largely on the amount and arrangement of the combustible materials. When it is reached, subsequent developments depend largely on the access of air to the fire.

There are two basic principles of practical fire protection, namely, the control of possible sources of ignition, and the control of the amount of combustible material that can be involved at one time. The latter frequently involves the division of large buildings into compartments each of which has a pre-determined degree of fire resistance.

Observations of the temperatures reached at many large fires, and in experiments, have led to the almost universal acceptance of a standard time-temperature curve which is considered to represent the conditions in a severe fire. 'Fire resistance' is defined as the length of time for which a unit of structure continues to perform its design function when it is heated in a furnace which is controlled according to the standard curve. By-laws in most countries now require buildings in towns to be constructed so that their walls, floors, structural columns, and certain doors and windows reach an appropriate degree of fire-resistance. Steel columns have a fire resistance of about ten minutes, and the problem is, therefore, to provide them with a heat-resisting coating which will stay in position when involved in fire.

It sometimes comes as a surprise to find that steel behaves so badly in fire; but it may be a greater one to learn that a number of fires have been caused by the combustion of fine steel-wool, which is readily ignited by a match, or even by allowing a handful to fall across the terminals of a small battery; and there have been many fires in boilers in which overheated steel tubes have burned in high-pressure steam.

The variety of possibilities in constructing fire-resistant buildings is so great, and the present state of our knowledge so small, that full-scale tests are often necessary before approval can be given for the use of a new form of building construction. Furnaces were built by the Fire Offices Committee nearly thirty years ago to enable such tests to be carried out, and they were immediately made available to the Building Research Station of the Department of Scientific and Industrial Research for research purposes. When the Joint Fire Research Organization was set up in 1947, they formed part of the contribution of the Fire Offices Committee to this Organization.

Fig. 2 shows a specimen after test, and gives an idea of the size of the operation. Such tests are costly and time-consuming, and much research has been designed to find means of eliminating them, or at least of conducting them on a smaller scale. The work has involved the search for mathematical expressions for the variations in temperature in every part of a wall, floor, column, etc., when the temperature at the surface is raised at the rate demanded by the standard time-temperature curve. The construction of these may be elaborate, and even when the thermal constants of the constituents are known the calculation of rise of temperature in the steel is a difficult

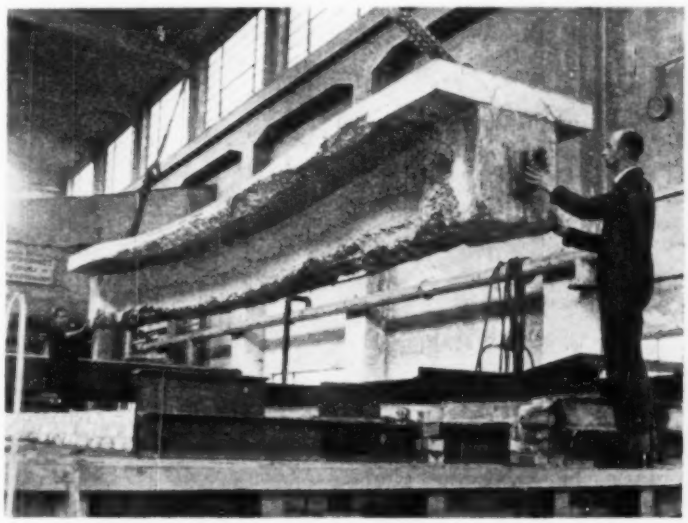

Fig. 2. Full-size specimen of pre-stressed concrete beam after fire resistance test. By courtesy of the Director of the Fire Research Station. Crown copyright reserved

and tedious operation. Lawson and McGuire devised and constructed an electrical analogue which has proved extremely valuable both as a research tool and in reducing the number of full-scale tests. It exploits the close analogy which exists between the flow of heat in solids and the flow of a charge along a transmission line composed of series resistance and shunt capacitance elements.

The analogue deals with one scientific problem, namely, the behaviour of units of building construction under closely defined conditions. There remains a wide range of problems resulting from the movement of hot gases and the transfer of heat, such as the provision of escape facilities in high buildings, the control of smoke in large basements or in ships, the 'mushrooming' of hot gases in buildings of large area, the detection of fire, and many aspects of extinction. Before these can be studied on a small scale there is need of a reliable technique for the use of models. Considerable progress in this direction has been made by P. H. Thomas and C. T. Webster. Working with similar cubical models, of 1–10 ft. side, they have studied the burning of wooden cribs of various sizes, and have established relationships that have already enabled them to deal with some practical situations.

It has long been recognized, for example, that smoke is perhaps the fireman's greatest enemy. It offers particular difficulties in buildings with a large expanse of floor area with all kinds of obstructions which together make it impossible for the fireman to see or to find his way to the seat of the fire. The Covent Garden fire and several other recent large fires in Great Britain have focused attention sharply on this problem. They have led to a revived interest in a method of fire protection that has been employed in theatres for many years, namely, the provision of emergency venting in the roofs to release the smoke and hot gases at an early stage in the fire. P. H. Thomas has recently developed for the first time what appears to be a satisfactory solution with an adequate theoretical basis. Using models, he has explored the combined use of 'curtains' to restrict the lateral spread of smoke in conjunction with roof-vents of various sizes, and has established a relation between vent area and the proportion of heat released in experimental conditions.

Detection

Experience of large fires soon convinces that, when they get beyond a certain size, total destruction is inescapable. A surprisingly large proportion of the total damage is caused by a relatively small number of large fires; each year nearly half the damage in the United Kingdom is caused by some 200–300 out of some 50,000 fires in buildings attended by the fire brigades. Of the many factors that contribute to the development of large fires the most important is failure to detect and attack them while they are still small. P. Nash and R. Pickard have explored the rise in temperature and the movement of hot gases over fires of various sizes in enclosures of various heights and shapes, a task which called for entirely new instruments for measuring air-flow. Using the results of this work, together with information about the distance of travel of fire brigades and experience of the desirable balance between high sensitivity and the likelihood of false alarms, they have succeeded in developing a standard procedure which enables the merits of new designs of detector to be assessed.

Before leaving the subject of the occurrence of fires, reference should be made to the fact that effective statistics are collected with the collaboration of the fire brigades of the local authorities, by arrangement with the Home Office. These have yielded a number of interesting results, including indications of significant differences in behaviour of pre-war and post-war houses and 'pre-fabs'—the post-war housing having the best record. They have revealed a steady increase in fires associated with electrical equipment, and with the use of certain types of oil-burning apparatus.

Extinction

When attempts to control sources of ignition and accumulations of fuel have failed, there remains the task of fire extinction. The most common method is to cool the fuel to a temperature at which the flammable vapours cease to be emitted.

The commonest extinguishing agent is water, and the principles that govern its use have not changed fundamentally over hundreds of years. Whenever it can be used, it is incomparably the best medium. There is plenty of it and it is cheap; it is easily transported (by pipes) and easily applied; it has a large thermal capacity and it boils at a convenient temperature, absorbing a useful amount of heat in doing so. The only circumstances in which plain water is not the best medium are electrical fires, fires involving flammable liquids the flash-point of which is below atmospheric temperatures, and circumstances in which water damage must be avoided at all cost.

The main lines of research in recent years have aimed at improvements in methods of applying water. Since the War improvements in equipment, training, and technique have resulted in a marked and continued steady improvement in the effectiveness of fire brigades in the United Kingdom.

In the early post-war years the opinion was held in some quarters that high-pressure sprays, which were believed to have very fine drops, represented the ultimate in efficiency. A long and careful study by D. Hird, in which the fire brigades in London and Birmingham took part, demonstrated that there is no material advantage in increasing operational pressure much above about 100 lb. per sq. in., and any theoretical merit fine drops may have in extinction is offset by their limited trajectory.

D. J. Rasbash has shown that, where water is used, fires in liquids which cannot be cooled below their flash-point can be extinguished in the vapour phase by the use of a very fine spray. Less-volatile liquids such as fuel oil can be extinguished by cooling, and larger drops which will pass through the flames and reach the surface of the liquid are more effective.

Another way of using water is as foam, which is made by dissolving a foaming agent (often a protein derivative) in water and aerating the solution mechanically, or by producing bubbles of carbon dioxide chemically. The function of the foam is to cover the surface of the liquid and to shield it against radiant heat from the fire, thus cutting off the supply of flammable vapour.

During the War it was found possible to introduce foam at the base of a tank of fuel oil, and to let it rise by its low relative density and spread over the surface of the oil. This was not possible with petrol, because in ascending through the bulk of the liquid the foam became impregnated with petrol, which continued to burn and destroyed the foam. Recent work has led

Fig. 3. Last stages of extinction in petrol fire by foam injected at the base of a tank 30 ft. high. By courtesy of the Director of the Fire Research Station. Crown copyright reserved

to the surprising conclusion that very sloppy foams, with an expansion of about three times, are effective even with petrol (Fig. 3).

Two other types of extinguishing agents are used for special fires. The first are known as vaporizing liquids, the commonest being carbon tetrachloride. They operate in the vapour phase by absorbing heat, and possibly also by inhibiting combustion. Research has been devoted to seeking to understand the reactions involved, and to seeking the most effective of a wide range of reagents. Taking into account cost, convenience, toxicity of the agent or its decomposition products, chlorobromomethane has come to be regarded as the best of the available materials.

D. J. Rasbash recently made the bold suggestion that the principle of controlling the atmosphere might be used on the grand scale even for such fires as that at Covent Garden. A large jet-engine was specially modified by the National Gas Turbine Establishment, and the exhaust gases from this engine are being used experimentally in a large building to see how far practical use can be made of the principle. The inert, exhaust gases do not cool the fuel, but it is hoped that they will prevent the spread of combustion long enough for a fireman to be able to approach with his hose.

The other type of medium is known as 'dry-powder', the commonest form being sodium bicarbonate. Research has not yet fully elucidated its mode of action, but experience has thrown considerable doubt on its superiority over other cheaper and better-known methods.

Fire as a Social Problem

Fire is a social problem. An example will illustrate the complications that are encountered in applying the results of research. A few years ago D. I. Lawson and his colleagues studied the occurrence of casualties through the ignition of clothing. Fire brigades and a number of hospitals co-operated by sending reports on a large number of incidents, and when possible they sent samples of the fabrics which were first ignited. The researches involved studies of a large range of fabrics in the laboratory, and a simple equipment was developed as a standard measure of their flammability. Statistics showed that nearly a quarter of the fatal casualties were children, and of those a large proportion were wearing nightdresses. Very few occurred between the ages of about 10 and 60, and the vast majority were elderly people and often old ladies. It became clear that the practical solution was not to aim immediately at the prohibition of all but flame-resistant fabrics; there was need for special care of the young and old, who might wear such materials, and increased attention to the control of sources of ignition such as electric fires, gas fires, and the domestic fire. It was considered important that the public should be informed about the special hazards of certain fabrics and that means should be provided for them to be able to recognize the ones which presented the least hazard.

Fire touches practically every aspect of life, and deliberations of this kind call for wide collaboration. Some fourteen Government Departments in Britain have special concern in fire protection: the Home Office is responsible for the safety of the public where they assemble in buildings and other places, and for ensuring that the efficiency of the fire brigades is maintained: the Ministry of Transport for safety in ships: the Ministry of Aviation for aircraft, and so on. The Fire Research Board gives opportunity for members of industry and of the universities to consider their problems and, with assessors from the Government departments, to ensure that the research programme is balanced and co-ordinated.

The Joint Fire Research Organization itself is believed to be the only example of complete and equal partnership of Government (through the Department of Scientific and Industrial Research) and industry (through the Fire Offices Committee) in arranging at national level for research to deal with a social problem.

OBITUARIES

Prof. Erwin Schrödinger, For.Mem.R.S.

ERWIN SCHRODINGER, who died on January 4, was a man with outstanding ability to apply abstract mathematical reasoning to the advancement of physical theory. His great discovery, namely, Schrödinger's wave equation, as the basis of the description of atomic processes, was one of the most surprising of all the sudden advances that have occurred with the development of scientific knowledge.

Schrödinger was born in Vienna in 1887. He was a student at the University of Vienna during 1906–10, and then acquired a mastery of eigenvalue problems in the physics of continuous media, so laying the foundation for his great work. He became assistant at the University of Vienna, and later served as an artillery officer during the First World War.

In 1920, having married Annemarie Bertel, he went to Jena to take up an academic position. This was followed by positions at Stuttgart (extraordinary professor), Breslau (ordinary professor), and then the University of Zurich, where he settled for six years. Throughout this period he was very actively engaged in research in theoretical physics and published many

papers, mostly on the specific heats of solids and other questions of thermodynamics, and on atomic spectra.

He has told me how he came to make his great discovery. With his work on spectra he was using, of course, Bohr's orbit theory, but he always felt that the quantum conditions in this theory were unsatisfactory and that atomic spectra should really be determined by some kind of eigenvalue problem. In 1924, de Broglie published his work on waves associated with the motion of free particles. This influenced Schrödinger profoundly, and he set to work to try to generalize de Broglie waves to bound particles. He finally obtained a neat solution of the problem, leading to the appearance of the energy-levels as eigenvalues of a certain operator. He immediately applied his method to the electron in the hydrogen atom, duly taking into account relativistic mechanics for the motion of the electron, as de Broglie had done. The results were not in agreement with observation. We know now that Schrödinger's method was quite correct, and the discrepancy was due solely to his not having taken the spin of the electron into account. However, electron spin was unknown at that time, and Schrödinger was very disappointed and concluded that his method was no good and abandoned it. Only after some months did he return to it, and then noticed that if he treated the electron non-relativistically his method gave results in agreement with observation in non-relativistic approximation. He wrote up this work and published it in 1926, and in this delayed manner Schrödinger's wave equation was presented to the world.

A short time previously Heisenberg had discovered his matrix mechanics, another formalism for dealing with atomic processes. The theories of Heisenberg and Schrödinger were soon found to be equivalent, there being a mathematical transformation that converts one into the other. Two independent and apparently entirely different lines of thought thus led to the same foundation for atomic physics.

Schrödinger published a series of papers in quick succession, developing his ideas. For this work he shared the Nobel Prize in Physics for 1933.

In 1927 he unfortunately moved to Berlin, where he became Planck's successor. In consequence his life became disturbed by political developments, and with Hitler's coming to power in 1933, he decided he could not continue in Germany. He came to England, and for a while held a fellowship at Oxford. In 1936 he was offered a situation at Graz. He was well aware of the uncertain position of Austria at that time, and it was a difficult decision for him to make; but the attraction of returning to his native country outweighed his caution and he accepted.

With the German annexation of Austria in 1938 Schrödinger was immediately in difficulty, because his leaving Germany in 1933 was taken to be an unfriendly act. He was forced to express his approval of the Nazi regime, and he did this in as ambiguous a way as he could (see *Nature*, **141**, 929; 1938).

He soon found life with the Nazis intolerable, and, profiting by the fact that they had neglected to take away his passport in the first place, he was able to slip across the frontier to Italy. He proceeded to Princeton University and after a short stay there moved to Dublin, to the newly created Institute for Advanced Studies, where he became director and remained until his retirement in 1955.

All this time Schrödinger continued his research and published many papers on a variety of topics. Some of them were concerned with unifying gravitation and electromagnetism, the problem which absorbed Einstein for many years and which is still unsolved. Schrödinger remained greatly interested in the foundations of atomic physics. He did not like the generally accepted dual description in terms of waves and particles, with a statistical interpretation for the waves, and tried to set up a theory in terms of waves only. This led him into controversy with other leading physicists.

Schrödinger was unconventional in his way of life. When he went to the Solvay conferences in Brussels, he would walk from the station to the hotel where the delegates stayed, carrying all his luggage in a rucksack on his back and looking so like a tramp that it needed a great deal of argument at the reception desk before he could claim the room that had been reserved for him.

After his retirement he returned to an honoured position in Vienna. He died after a long illness. He is survived by his wife, who was his faithful companion throughout their marriage.

P. A. M. Dirac

Dr. Sidney Marsh

Dr. S. Marsh, who was head of the Physics Department of Battersea Polytechnic from 1919 until 1950, died on December 14, at the age of seventy-six.

After completing a double first in physics and mathematics at University College, Cardiff, he went to Munich and Göttingen, where he obtained his Ph.D. on work on discharge tubes under Prof. E. Riecke. He joined the staff of Battersea Polytechnic in 1909 and, except for the two years 1917–19, when he was head of the Mathematics and Physics Department at Rutherford Technical College, Newcastle on Tyne, he remained there until his death. He was appointed head of the Department in 1919, and, after his retirement in 1950, he continued as a part-time lecturer giving more than part-time service. He gave his last lecture on December 12, 1960, two days before his death. The way he continued to adapt himself to the rapidly changing conditions of work in the post-war period was very remarkable. Old regulations and new regulations, general and special degree, polytechnic and college of advanced technology, he took it all in his stride.

His research interests lay in electrolysis and gas discharges, but the passion of his life was teaching, and, while this goes unrecorded in the proceedings of learned journals, it lives on in the hearts and minds of all those that passed through his Department during his long stay there. With immense energy he also threw himself into the examination work of the University of London, and for many years right up to his death he was the mainstay of the external examinations in physics. Marsh must have been a name to countless students, the world over, who never knew of the immense pains he took to be fair to them and the compassion with which he carried out his duties as an examiner.

As a young man taking over what had been his Department for so long, I might have expected to find him a little difficult as a colleague. Far from this being so, he was a most kindly and considerate person who was never obtrusive with his advice, though always willing to give it. He had that true humility that is a token of true greatness, and those who have known him and have worked with him mourn his loss greatly.

L. R. B. Elton

Mr. H. T. Pledge, C.B.E.

By the death of Mr. H. T. Pledge on December 28, the library and scientific worlds have suffered a great loss.

Humphrey Thomas Pledge, son of Thomas Pledge, was born on November 6, 1903. He went to Tonbridge School and thence as an Exhibitioner to Trinity College, Cambridge, where he took a first in the Natural Sciences Tripos. After a short period of teaching at Wrekin College he entered the Science Museum Library as an assistant keeper in 1928.

During his early years in the Library, Pledge was concerned with its services to industry, both in lending and in providing information. It was during this time that he collected material for his major work, published by H.M. Stationery Office in 1939, under the title *Science since 1500*. This is a comprehensive and masterly historical survey of the development of the physical and biological sciences, which has been widely accepted as a standard book of reference. It has been reprinted three times in Great Britain and has also been published in the United States.

In 1945, Pledge became keeper of the Science Museum Library, and the full burden of the restoration of its services after their dislocation during the War fell on his shoulders. Later developments which added to his administrative responsibilities were the photocopying service and the impact on the Science Museum Library of the formation of the National Scientific Lending Library to take over gradually the former's lending service to industry. During his tenure of the keepership he continued to build up the Library into one of the finest scientific libraries in Britain, in spite of stringent limitations on the financial resources available to him.

Pledge's interests were wide, ranging from biography through the physical and biological sciences to ethnology and archaeology, and his knowledge was deep. His book brought fellow workers on the history and philosophy of science from all over the world to South Kensington to visit him. He took an active part in the founding of the British Society for the History of Science.

In 1934, Pledge married Ruth, daughter of the Rev. H. M. Brown, and they had one daughter. He was made a C.B.E. in 1960. S. E. JANSON

NEWS and VIEWS

U.S. Atomic Energy Commission : Dr. Glenn T. Seaborg

DR. GLENN THEODORE SEABORG, who has been appointed chairman of the U.S. Atomic Energy Commission, was born in Ishpeming, Michigan, on April 19, 1912. After graduating at the University of California in chemistry in 1934, Dr. Seaborg held various research and teaching appointments in that University until 1942, when he was appointed section chief in the Manhattan Engineer District's Metallurgical Laboratory at the University of Chicago, where he conducted research in nuclear chemistry and physics; here he was responsible for developing the process used for the separation of plutonium from fuel elements irradiated in the production reactors at the Hanford installation at Richland, Washington. In 1946 he returned to the University of California at Berkeley as a professor in the Department of Chemistry. He was appointed chancellor of the University in 1958.

While serving as instructor at the University of California in 1940, Dr. Seaborg was co-discoverer of element 94 (plutonium), the first of a number of trans-uranic elements which his research activities revealed over the next fifteen years. He was the discoverer in 1941 of the isotope used as a source of nuclear energy, plutonium 239; in 1942 of the uranium isotope, uranium 233; in 1944 of elements 95 (americium) and 96 (curium); co-discoverer in 1949 of element 97 (berkelium); co-discoverer in 1950 of element 98 (californium); in 1952 of element 99 (einsteinium); in 1953 of element 100 (fermium); and in 1955 of element 101 (mendelevium). He was a member of the Atomic Energy Commission's General Advisory Committee from 1946 until 1950; member of the Joint Commission of Radioactivity, International Council of Scientific Unions, since 1946; and of the Committee of Standards and Units of Radioactivity, National Research Council, since 1947.

Anatomy and Biology at Western Reserve University

PROF. MARCUS SINGER has been appointed Henry Willson Payne professor of anatomy in Western Reserve University, Cleveland, Ohio. He is at present professor of zoology and of child development and family relationships in Cornell University. Prof. Howard A. Schneiderman, associate professor of biology in Cornell University, has been appointed professor of biology in Western Reserve University. Both appointments will be effective July 1, 1961.

A native of Pittsburgh, Prof. Singer first graduated from the University of Pittsburgh, and later was awarded M.A. and Ph.D. degrees by Harvard University. He was on the Harvard staff during 1938–51, first in the Biology and Zoology Departments and later in the Anatomy Department of the Medical School. In 1950 he served as visiting professor at the Long Island College of Medicine in Brooklyn, New York. He went to Cornell as associate professor of zoology and of child development and family relationships in 1951 and became a full professor in 1953.

Prof. Schneiderman is a native of New York City. He attended Swarthmore College and Columbia University and graduated from the former in 1948 with honours in mathematics and natural sciences. He was granted the degree of M.A. and a doctorate by Harvard University. During 1952–53 he was a University research fellow in biology at Harvard. In 1953 he was appointed assistant professor of zoology at Cornell and was appointed associate professor in 1956.

Botany at Calcutta : Prof. S. M. Sircar

DR. S. M. SIRCAR has recently been appointed Sir Rashbehari Ghosh professor of botany in the University of Calcutta. This chair, created in 1914 in the name of its donor, is the oldest in Indian universities for fostering research work in botany

with special reference to agriculture. Dr. Sircar was educated at the Presidency College and the University College of Science, Calcutta. During 1934–36 he worked under Prof. F. G. Gregory, at the Imperial College of Science and Technology, London. After returning to India in 1937 he joined the University College of Science, Calcutta, and took active interest in organizing research in plant physiology, particularly with reference to the rice plant. During 1946–47 Dr. Sircar served as acting head of the Department of Biology in the University of Dacca and from 1949 until 1951 he was on deputation with the Government of India as professor of agricultural botany in the Central College of Agriculture, New Delhi. He has created a strong school of research in Calcutta with special reference to vernalization, photoperiodism, mineral nutrition, germination and auxin relations of the rice plant. In 1954 he was elected a Fellow of the National Institute of Sciences of India. In 1958 he was awarded a travel grant by the Rockefeller Foundation to visit various universities and research institutes in Europe, the United States and Japan. The appointment of Dr. Sircar to the chair is a fitting recognition of his long association with the University of Calcutta and his continued interest in the rice plant.

School of Management Studies, University of Bristol

The University of Bristol is to establish a School of Management Studies for the purpose of providing residential courses in management studies and for conducting research into problems of business management and administration. This has been made possible by an offer by the Foundation for Management Education to underwrite the sum of £14,500 a year for a period of seven years in support of the School, and by the agreement of the University Grants Committee to supplement the Foundation's support with a contribution of its own. The initial programme for the School will be the offer of a residential course for executives in the 28–34 age group, who have attained departmental responsibilities and who are nominated by their employers as being suitable for the kind of training which the School will provide. The course will be of eight weeks duration, divided into two periods of four weeks each, these periods being separated by an interval of about ten weeks, during which the students concerned will be expected to undertake specified studies within their own employing organization. It is intended that the session 1961–62 will be occupied as a preparatory year for the School and its first admissions should be in the autumn term of 1962. Further information can be obtained from the Registrar, University of Bristol, Bristol 8.

Scientific Literature on Fire

The tenth volume of *References to Scientific Literature on Fire* has recently been published by the Fire Offices' Committee, Joint Fire Research Organization (Library Bibliography No. 5/Part X. By Miss E. M. Shakeshaft and Mrs. B. F. W. Rogowski. Pp. 107. Boreham Wood, Herts: Fire Research Station, 1960). This contains 1,117 title references to papers, most of which appeared in 1956, arranged under eight headings. The largest section (311 references) is entitled "Initiation and Development of Combustion", and refers mainly to original and fundamental studies. Other sections are devoted to branches of fire technology—occurrences of fire (103 references), fire hazards (106), fire precautions (149), fire resistance (178) and fire fighting (229). Short sections headed "Atomic Energy" (18 references ranging from radioisotopes to nuclear weapons) and "General" bring the volume to a conclusion, except for extensive name and subject indexes which occupy as much as two-fifths of the whole publication and have evidently been compiled with much care and thought. There is no doubt that this series fulfils a useful purpose, especially as regards the fire technology references, most of which would not be found in other bibliographies.

Royal Society Committee on Scientific Research in Schools

The Committee on Scientific Research in Schools which was established by the Council of the Royal Society in 1957 has issued a report covering the period November 1, 1959–October 31, 1960. It is stated that interest shown by schools in undertaking research has continued to increase, and the Committee is now administering research projects in 56 schools. Some of these schools have more than one research project under way and a total of 66 separate research projects are now being actively pursued compared with 57 last year. During the year, £2,000 has been provided by the Council of the Royal Society, and Shell Research Ltd. have given an additional £75 for special assistance at one school. All research projects with which the Committee is dealing are carried out with the specialist advice and assistance of Fellows of the Society and by others who act as advisers. The Committee invites further requests from school-masters and school-mistresses for assistance in undertaking research. A list of the schools at which research projects are being carried out and a list of the projects themselves—which cover a very wide range of topics in the physical and biological sciences—are given as an appendix to the report.

North Atlantic Biogeography

The American Geographical Society, working together with a panel set up by the Committee on Oceanography of the U.S. National Academy of Sciences–National Research Council, proposes to publish a scientific journal of an unusual kind, tentatively called *North Atlantic Biogeography*. The journal will consist of maps, accompanied by such explanatory text as may be necessary, and will appear irregularly as contributions are received and accepted. It will be a medium for publication of studies of all kinds—biological, geological, physical, chemical—that will illuminate our geographical understanding of the marine environment. Its scope will be limited to the Atlantic marine areas from the equator to the pole and will include the Arctic basin. The plan is sponsored in the United States by the National Academy of Sciences—National Research Council, and in Canada by the Royal Society of Canada. Funds are being sought in both countries. The panel is international. Further information can be obtained from the Director, American Geographical Society, Broadway at 156th Street, New York 32.

Botanical Garden, Allahabad

A new botanical garden has been established at Allahabad in the premises of the Central Botanical Laboratory, Botanical Survey of India. The garden is divided into various sections such as an economic

plants garden, experimental garden, ornamental section, landscape section, lily pools, fern houses, orchidarium and nursery. The temperature and humidity are being manipulated in the fern houses and orchidarium by artificial fountains and green cover. A variety of species is being introduced in the different sections. The institution is establishing exchange relations for seeds and plants, and it may be possible in the near future to publish an inventory of the seed and plant material available. Gifts of seeds and plants will be welcomed by the Director, Central Botanical Laboratory, Allahabad, India.

Efficiency of Indexing Systems

THE report on the first stage of an investigation into the comparative efficiency of indexing systems issued in September 1960 (see *Nature*, **188**, 276; 1960) has now been followed by an interim report on the test programme briefly outlined in that earlier report (Aslib Cranfield Research Project: *Interim Report on the Test Programme of an Investigation into the Comparative Efficiency of Indexing Systems*. (An investigation supported by a grant to Aslib by the National Science Foundation.) By Cyril W. Cleverdon. Pp. iii + 84. (Cranfield: College of Aeronautics, 1960.) 8*s*. 6*d*.). For this programme more than 1,400 questions were received, from which 400 were selected for the first round of testing, about half relating to aerodynamics. Although the test programme is still incomplete and the clerical analysis of such testing as has been done is unfinished, the general level of the four indexing systems is of particular interest and possible surprise. There also appeared to be only a small difference between the success of the postings for the short time of 2 min. as against the relatively long time of 16 min. Comment is also made on the ability of a relatively inexperienced person to index with an efficiency equal to that of the other more experienced members of the staff. Comments on the general level of efficiency are in this report based solely on finding the same document, and indicate that technical staff were able to use the indexes as efficiently as the project staff, the only significant difference being with the alphabetical subject catalogue. Technical staff with no previous experience got on surprisingly well with the Universal Decimal Classification, but in regard to the facet system opinion is provisionally expressed that the chain index and single order approach were a severe handicap and that use of the schedules in a more conventional manner would have given more satisfactory results. Both the project staff and technical searchers found the uniterm system relatively simple to use.

Calcutta School of Tropical Medicine

THE joint annual report of the Calcutta School of Tropical Medicine and the Carmichael Hospital for Tropical Diseases for 1958–59 contains a full record of the work of the scientific staff of the many departments. A number of matters of outstanding importance are referred to. Among these was the breeding of a strain of black mice by the crossing of white and ordinary mice; these were used for transmission of human leprosy bacilli, with promising results. A new experimental device has been evolved for research on amœbiasis. In an attempt to produce better vaccine for cholera, it is recorded that formalin, in a suitable concentration, appeared to preserve antigenicity better than other chemical or physical agents. In the field of virus research, an interesting observation has been made. While the vaccinia virus was invariably found to be lethal to infant mice inoculated intracerebrally, the variola virus was found to survive in the brain of mice for a prolonged period without producing any pathogenic effect. Intensive work continued on the haemoglobinopathy syndrome, yielding results of considerable interest.

Medical Aspects of the Kariba Dam

A SPECIAL supplement of the *Central African Journal of Medicine* describes medical aspects of the Kariba Hydro-Electric Scheme (**6**, No. 10; October 1960). The paper has been prepared by Dr. M. H. Webster, formerly chief medical officer to the Federal Power Board, Kariba, who outlines the measures taken to deal with the health problems of the Kariba scheme stemming from the following factors: the topographical and meteorological features of the site; the nature of the undertaking; the importation of African workers in large numbers and at high speed from many parts of Central Africa; the importation of large numbers of European operatives who could be expected to have little or no immunity to the specific disease risks likely to be encountered and, indeed, as it turned out, little or no experience of tropical conditions. One of the first undertakings of the Board was a campaign, carried out from the air and on the ground, against the tsetse fly and mosquitoes which infested the area. As soon as possible an adequate hospital was built, but its modern equipment and comprehensive facilities would have been of little use without the skill and devotion of its staff. In a foreword, Sir Duncan Anderson, chairman of the Federal Power Board, states his belief that the study will prove a valuable source of information and guidance to all engineers and administrators who are concerned with the planning of great projects in the remote corners of the Earth.

The Quelea

IN many regions of Africa the quelea bird has always been a threat to agriculture, causing damage to crops, especially sorghum, millet, rice and other small-grained cereals. The economic losses have increased considerably during the past fifteen years or so, and to-day, in many African countries, more especially those of West Africa, all attempts to raise output are doomed to failure unless methods for the effective control of these birds are jointly elaborated and simultaneously applied. This was the problem before the symposium arranged by the Commission for Technical Co-operation in Africa South of the Sahara, held at Bamako during May 17–21 (*Science Afrique*, 21; July 1960). The agenda covered three main points: a review of progress achieved in control techniques—chemical, physical and biological means of destruction of roosts and breeding colonies; co-ordination at regional and interterritorial level—co-ordination concerning local migrations, ringing campaigns, direct exchanges of information on biology and control between neighbouring territories; control of birds other than quelea presenting a threat to crops. The participants were also called on to consider the possibility of developing joint action in Africa to combat this natural scourge. In their recommendations, they pointed out that progress in quelea control must depend on adequate financial means to apply really effective measures. The meeting also stressed the importance of direct exchanges of

information between technicians working in this field, and more especially between technicians in contiguous regions. A ringing programme was recommended to include at least 100,000 birds over a period of three years, and a budget drawn up for such a programme. Another recommendation dealt with the need for investigations on the physiology and parasitic diseases of quelea as being indispensable in determining fresh control methods.

New Stomatopod Crustaceans in West Africa

In November 1956, Dr. D. T. Gauld, of the University College of Ghana, sent to the British Museum (Natural History) three small Stomatopods, collected at Labadi, West Africa. One of these proved to be an immature specimen of a *Lysiosquilla*; the other two specimens were labelled *Squilla pallida*, but this identification proved to be incorrect. Later, two further specimens identical with those submitted by Dr. Gauld were found among a collection of *Squilla africana* Calman from Accra. It was apparent that these four specimens belonged to an undescribed species of *Squilla* as they did not agree with any known West African species, or with the descriptions of any of the known Eastern Atlantic ones. The name *Squilla labadiensis* has been given to this new species, which is described by R. W. Ingle in the September issue of *Annals and Magazine of Natural History* (2, No. 21; 1960). During the course of describing *Squilla labadiensis*, Ingle re-examined several West African specimens of *Squilla* in the British Museum (Natural History) collections. In particular, among a collection presented to the Museum by Mr. A. R. Longhurst, it was discovered that several specimens labelled *Squilla mantis* had been wrongly determined, and these specimens were identified as *Squilla intermedia* Bigelow, hitherto known only from the Gulf of Mexico and Little Bahama Bank, and the range of which is now extended to the West African coast. The description of *Squilla intermedia* is included in the paper.

Canavanine in Leguminosae

The amino-acid canavanine is known to be present in the free state only in members of the Leguminosae. It occurs in the seeds and its synthesis has been reported in rooted leaves of *Canavalia* sp. Its presence can be detected by simple chromatographic techniques. B. A. Birdsong, R. Alston and B. L. Turner have now reported on a systematic study of the distribution of this substance in 161 species, representing 78 genera, of Leguminosae, and have discussed the impact of their findings on the phyletic grouping in this family. These results are supplemented by data, variously collected, by other authors, to yield a total of 219 investigated species representing 109 genera. Of these, 68 species belonging to 32 genera have canavanine in their seeds. Canavanine has not been found in the sub-families Mimosoideae or Caesalpinioideae. In the sub-family Papilionoideae it has not been found in the tribes Podalyrieae and Sophoreae. At least one species from each of the other tribes produces canavanine. In three genera, some species produce canavanine whereas others do not. These data are presumed to be of taxonomic significance and have been interpreted as support for chromosomal information, indicating that the tribes Mimosoideae and Caesalpinioideae diverged relatively early from the 'stem' line which is now represented by the Papilionoideae (*Canad. J. Bot.*, **38**, 499; 1960).

New Nature Reserve

The Nature Conservancy has declared a new national Nature reserve of 1,363 acres at Invernaver, near Bettyhill, on the north coast of Sutherland. The reserve includes woodland, heath and sand-dunes. Its subsoil is limestone, and this brings in a number of rare and local plants, including the Scottish primrose *Primula scotica*, the mountain avens *Dryas octopetala*, and the purple mountain milk-vetch *Oxytropis halleri*. The attractive little spring squill *Scilla verna* also grows in the reserve, and there is a moss that grows nowhere else in Britain. The breeding birds of the reserve include the greenshank, red-throated diver and ring ouzel.

Symposium on Zooplankton Production

Following the success of the symposium on primary plankton production held in Bergen in 1957, it is proposed to hold a symposium in Copenhagen in 1961 entitled "Zooplankton Production". It will be held towards the end of the annual session of International Council for the Exploration of the Sea during October 8–10. The symposium is planned to include: two sessions on methods of estimating zooplankton, methods used at sea and in the laboratory, methods of assessment of standing crop and production; one session on the food of zooplankton, the trophic relationships of the organisms, and regeneration of nutrients; one session on behaviour, including vertical migration, distribution, speed of movement and zooplankton as a possible source of sonic scattering layers; one session left open for extra papers and discussion of recommendations. To keep within the schedule, and yet allow time for the very valuable discussions, the papers at the first four sessions will be by invited speakers only. Papers for consideration for the fifth session will be welcomed, at this stage by title only with a paragraph of explanation if this is not clear in the title. The organizing committee includes: Dr. J. H. Fraser (convener), Marine Laboratory, P.O. Box 101, Victoria Road, Aberdeen; Prof. E. Steemann Nielsen (Copenhagen); Prof. J. Krey (Kiel); Dr. Gunnar Thorson (Helsingor). Those who intend to be present should notify the convener as soon as possible.

"Educating the Whole Man"

In an article, "The Problem of Freedom and Efficiency in Universities", in *Science and Freedom* for October and in a broadcast talk, "Dry Rot and Redbrick", Dr. A. P. Rowe pleaded earnestly for a thorough reconsideration of the relations between teaching and research in British universities. He suggested a searching inquiry into the quality of both, as well as into the balance between them, and also that changes in the structure of the administration of the universities might facilitate the promotion of more effective and stimulating teaching, and the elimination of much of the trivial investigations which now pass for research. A sentence in the leading article in *Nature* of January 7 (p. 2) unwittingly misrepresents Dr. Rowe's mind. So far from rejecting any idea of a broad education, he is concerned that the universities of Great Britain are failing to provide that vital something that was once given by the homes from which their students came; and although he advocates that more research should be carried out in research institutes rather than in university departments, such institutes should be, he thinks, an integral part of the university.

D.S.I.R. Studentships, Fellowships and Research Grants: 1961

Two booklets, issued by the Department of Scientific and Industrial Research, have become available and give detailed information on grants to be offered by the Council for Scientific and Industrial Research during 1961 for studentships, fellowships and special research. The first, entitled *D.S.I.R. Studentships and Fellowships, 1961*, gives the information required by young scientists and technologists who wish to obtain grants in order that they may continue their training beyond their first degree (Pp. 28. London: H.M. Stationery Office, 1961. 1*s.* 9*d.* net). Information is also given of awards made available by the Council and tenable abroad, and of Nato science studentships and fellowships. In most cases it is required that applications for these grants be made by March 1. The second booklet, entitled *D.S.I.R. Research Grants, 1961*, gives information on grants for special research work (Pp. iv+8. London: H.M. Stationery Office, 1961. 1*s.* net). This covers such grants as are applicable to investigators who are already of acknowledged standing in their subjects. Applications for these grants should be submitted to the Council by May 1 or November 1. Grants issued by the Department of Scientific and Industrial Research are essentially for British subjects normally resident in the United Kingdom, but in certain cases the Council will consider persons of other nationalities who are working in the United Kingdom.

Lady Tata Scholarships and Fellowships

The Trustees of the Lady Tata Memorial Trust invite applications for grants, scholarships and fellowships for research on diseases of the blood, with special reference to leukæmia, in the academic year beginning October 1. In view of the affinity between leukæmia and other forms of neoplastic disease, candidates with programmes of research on any aspect of malignant disease which may throw light on problems of leukæmia will be eligible for consideration. The Trustees specially wish to encourage studies of the leukæmogenic viruses in mammals, the epidemiology and natural history of leukæmia, and the genetical and cytological aspects. Further information can be obtained from the Secretary of the (European) Scientific Advisory Committee, Lady Tata Memorial Trust, Chester Beatty Research Institute, Fulham Road, London, S.W.3. Applications must be submitted before March 31.

"Radiative Recombination in Gallium Phosphide Point-Contact Diodes"

Drs. H. C. Gorton, J. M. Swartz and C. S. Peet write: "The acknowledgment to the United States Air Force, which sponsored the work reported in the communication under this title published in *Nature*, **188**, 303 (Oct. 22, 1960), through subcontract with the Lincoln Laboratory, Massachusetts Institute of Technology, was inadvertently omitted. Appreciation is hereby expressed to the Lincoln Laboratory for permission to publish this work".

"Labilization of Deoxyribonucleic Acid in Thymus Nucleoprotein after Whole-body Irradiation"

Referring to the communication under this title in *Nature*, **187**, 1123 (1960), Dr. Ulrich Hagen writes: "In the text, Fig. 1 and in Tables 1 and 2, the extraction of DNA is described as being done with 'trichloracetic acid'. It must be emphasized that the sodium salt of trichloracetic acid was always used, at the concentrations mentioned (0·5, 1·0... per cent). The *p*H-value of the solution was 6·7".

Announcements

Prof. Theodore von Kármán, at the California Institute of Technology, has been awarded the 1961 James Watt International Medal of the Institution of Mechanical Engineers, in recognition of his contributions to the advancement of mechanical engineering science in the field of aeronautics. The award of the Medal is made every two years.

Dr. E. K. Janaki Ammal has been awarded the Indian Botanical Society's Birbal Sahni Medal. The Medal is awarded every year to a distinguished Indian botanist for his contributions and services to botany in India.

Volume 4, Part 4, *of Scientific Institutions and Scientists in Latin America*, issued by the United Nations Educational, Scientific and Cultural Organization, Scientific Co-operation Office, Montevideo, lists the scientists of Argentina, *N–Z*, giving the usual particulars of career, research activities and publications (Pp. 453–706. Montevideo: Unesco, Centro de Cooperacion Cientifica para America Latina, 1960).

Industrial Abstract, No. 47 (November 17, 1960), issued by the Technical Information Section, Federal Ministry of Commerce and Industry, Lagos, Nigeria, includes the abstracts classified according to the Universal Decimal Classification, indicated by its title. There are also a review of the fourth edition of the *Handbook of Commerce and Industry in Nigeria* and a list of industrial, scientific and commercial fairs, exhibitions and conferences, November 1960–February 1961 (Pp. ii+26. Lagos: Federal Ministry of Commerce and Industry, 1960).

The Clay Minerals Group of the Mineralogical Society is holding a joint meeting with the British Society of Soil Science in the School of Agriculture, University of Cambridge, during April 6–7. The subject for discussion will be "Weathering". Further information can be obtained from Dr. R. M. S. Perrin, School of Agriculture, University of Cambridge.

The Advisory Committee on Arid Zone Research and the World Meteorological Organization are jointly organizing a symposium on "Changes of Climate" at the headquarters of the Food and Agriculture Organization, Rome, during October 2–7. The symposium is being arranged with special reference to Arid Zone Research. Further information can be obtained from W. Moller, Arid Zone Unit, Department of Natural Sciences, Unesco, Place de Fontenoy, Paris-7e.

A conference is being organized jointly by the Colour Group, the Institute of Physics and the Physical Society and the Inter-Society Color Council of America, to celebrate James Clerk Maxwell's demonstration of trichromatic colour reproduction at the Royal Institution in London. The conference will be held at the Imperial College of Science and Technology during May 16–18. Further information can be obtained from the Institute of Physics and the Physical Society, 1 Lowther Gardens, Prince Consort Road, London, S.W.7.

SCIENCE PLANNING, DEVELOPMENT AND CO-OPERATION IN THE COUNTRIES OF THE MIDDLE EAST AND NORTH AFRICA

A REGIONAL conference on the above topic was held under the auspices of Unesco and the United Arab Republic Science Council in the Senate Hall of the House of Representatives, Cairo, during December 19–23. The meeting was organized by the U.N. Science Co-operative Office of the Middle East (director, Mr. Jan Smid) and the United Arab Republic Science Council (secretary-general, Dr. A. F. Ismail). The meeting was attended by delegates from Iraq, Jordan, Lebanon, Morocco, Sudan, Tunisia, Turkey and the United Arab Republic. Three international scientific consultants were in attendance —Prof. J. Coulomb, directeur-général, Centre National de la Recherche Scientifique, Academician M. M. Dubinin, Academy of Science, U.S.S.R., and Prof. M. Stacey, Mason professor and head of the Chemistry Department, University of Birmingham.

The meeting was opened by an address of welcome from the Egyptian Central Minister of Education, His Excellency Kamal El Din Hussein, who discussed the need for co-operation in science and technology at regional and international level, and who emphasized the importance of such a conference for the future development of Middle Eastern and North African countries.

He was followed by Mr. Jan Smid, who spoke of the role of Unesco in the development of scientific research throughout the world. He outlined Unesco's efforts in trying to solve problems of economic planning in the less-advanced countries. He indicated the aims of the Conference as being of particular value in assisting the delegates to set up in their own countries some form of permanent centralized national body for co-ordination of scientific research aimed at better economic development of natural resources.

He emphasized the role of the international consultants. They were present to give their views on science administration based on their experience.

Each of the consultants then gave a short address on science planning and administration within his own country.

After an intermission, Dr. M. A. Haseeb of the Sudan was elected chairman of the conference and the elected vice-chairmen were delegates from Iraq and Turkey. Dr. A. F. Ismail of the United Arab Republic was elected recorder of the meeting. During the following two days delegates gave extensive reports on what was happening in science in their own countries. These may be summarized as follows:

Iraq. Delegates Dr. A. T. Al-Najim, director-general of education, Baghdad; Dr. F. Al Tai, dean of science, University of Beghdad.

The University of Baghdad was prominent in leading some research activities, and there were two research institutes in the country. Studies in agriculture and forestry were prominent and so were science and medicine. A number of research centres for industry, for example, for petroleum chemistry, were already planned, and schemes were in hand for atomic studies. There was a serious lack of trained scientists and technicians. Much thought was already being given to planning the national effort.

Jordan. Delegates Dr. S. Nashef, director of research, Ministry of Agriculture; Mr. A. Fouzi, under-secretary, Ministry of Public Works.

Jordan had no university, but there was a growing awareness of the importance of scientific research for the future development of the country. Various ministries had undertaken important research projects, for example, in agriculture, health, public works, etc. The Jordan Development Board, through its planning committee, was undertaking much research. Many industrial firms such as the Potash Co. were applying results of research. Many students were being trained abroad.

The country was beset with many difficulties. There was an urgent need for a central body for co-ordinating and financing research. There was a serious lack of scientists and trained technicians and a need for raising the status and salaries of those they had at present.

Lebanon. Delegates Mr. Joseph Naggar, president of the Central Scientific Commission for Lebanon; Dr. M. Attie, director, Industrial Research Institute.

There were three universities in Lebanon: (1) The Lebanon University, a recent foundation with quite well-equipped laboratories for research, especially in chemistry, physics and biology. (2) The American University with well-equipped science laboratories and with attached Schools of Engineering, Medicine, Agriculture and Economics. (3) The University of St. Joseph—a French University with good departments, but now lacking in funds.

There are a number of research institutes and also two good observatories. Scientific research in Lebanon lacks co-ordination, and urgently needs planning at the national level.

Morocco. Delegate Dr. Abdel L. Bennis, director, Agronomical Research Centre of Rabat.

There are a number of scientific research institutes in Morocco, for example, the Laboratory of Chemistry and Physics with divisions of hydrology, biological chemistry, hygiene, etc. There are also Laboratories of Parasitology, Entomology, Microbiology and General Biology. There are Departments of Botany, Chemistry, Geology (with an Institute of Geology) in what is termed the Faculty of Science of Morocco. An Agricultural Research Institute is under the care of the Ministry of Agriculture. There is a scientific institute, L'Institut Scientific Cherifeon, which was founded in 1921 with the object of co-ordinating science, and it has done valuable work in many disciplines and has given help with founding libraries, museums, etc.

There is a great need for a central science council for which the Government has now given approval. There was a grave shortage of scientists and technicians.

Sudan. Delegates Dr. M. Ali Haseeb, assistant director of research, Ministry of Health; Mr. A. A. El Karib, assistant director, Ministry of Animal Resources.

This country has 11 million people spread out over a million square miles. Its climate varies from desert

to tropical and subtropical and it has rich natural resources of minerals and agricultural products. Cotton is the main export.

The University of Khartoum is well established, and is very active in many faculties such as Science, Agriculture, Engineering, Veterinary, Arts and Law. A good deal of research is applied for national needs. There are many institutes of the various ministries which carry out research, for example, Agriculture, Irrigation, Animal Resources, Tropical Medicine. The Government is sympathetic to potential developments through science. Many more scientists and technicians are needed in the country.

Tunisia. Delegates Mr. Hamza, head of the Faculty of Sciences, director of research on arid zone problems, University of Tunis; Mr. Talbi, professor, Faculty of Letters and Science, University of Tunis.

The country has some traditions in science, for the Pasteur Institute of Tunis was created many years ago. Researches in the natural sciences, etc., have been carried out in institutes under various ministries, for example, of Education and Agriculture. Connexions with France have been close, and results of researches have been published in French scientific journals. Now a University of Tunis has been created (March 1960) which, although needing 10 years to build, will cater for 15,000 students and will have powerful science faculties and research facilities. The general outlook for science collaboration in Tunisia is promising.

Turkey. Delegates Prof. H. N. Pamir, University of Istanbul; Prof. N. Serdaroglu, Technical University, Istanbul.

Scientific research is carried out in the Universities, in laboratories attached to ministries and at a few special institutes. There are six Universities—Istanbul, Ankara, d'Ego, Ataturk, the Technical University at Ankara and the Technical University of Istanbul. Between them most scientific disciplines are taught, and research facilities are good. Most specialists' subjects such as agriculture are studied in the Ministry Laboratories, of which there are eight. The special research institutes are medical, for example, for tuberculosis and cancer. Much thought is being given at present to the formation of a council for science, but many difficulties must be overcome.

United Arab Republic. Delegates Dr. A. R. Tourkey, director, National Research Centre, Cairo; Dr. M. M. Ahmed, vice-rector, University of Cairo; Dr. A. F. Ismail and Dr. M. K. Tolba, Science Council; and Dr. M. B. Ahmed, University of Cairo; Dr. Y. Khouri and Dr. S. Al Safadi, University of Damascus.

Comparatively speaking, the United Arab Republic is very well organized, and the powerful Science Council which co-ordinates science in Egypt and Syria has just published its third annual report together with a report to Unesco. Both of these make impressive reading. The five Universities—Cairo, Ain Shams (Cairo), Alexandria, Assiout and Damascus—are all being considerably expanded, especially on the research side. The building of the large science centre in Cairo is well advanced, and there are many other research institutes, for example, for atomic research.

The projects being attempted are largely aimed at developing natural resources and are making good progress. The United Arab Republic is already playing the part of a centre of scientific training for the region. Its own problems, however, are still very great: especially a need for more high-quality scientists to act as research leaders, for skilled technicians, for better information and library facilities, for expensive apparatus, etc.

In the lively discussions which followed, many important and not unfamiliar points emerged. It was clear that there is already a good foundation in most countries on which sound national and regional developments in science can be built. There is urgent need for firm and substantial government support, for fair treatment of scientists and for good co-operation through Unesco.

Finally, it was possible for the conference to pass the following Resolutions:

(1) That a central science council or a similar body should be established in each Member State with the aim of organizing, reinforcing and co-ordinating pure and applied scientific research as well as promoting research projects leading to the economic, social and intellectual development of the nation.

(2) That this council or body has public utility status and financial autonomy, and is directly attached to the office of the Prime Minister, having a limited membership including representatives of universities, interested ministries and scientific institutions as well as certain scientists and experts in industry and agriculture.

(3) That the Member States allocate to this council a sufficient budget which would enable it to accomplish its mission, and that total expenses for scientific research in the country are progressively increased in order to attain not less than 1 per cent of national income.

(4) That this central body should first make use of the existing research institutions by improving their possibilities and promote establishment of new laboratories in fields essential to national needs.

(5) That this council establishes the priority of various projects of applied research of national importance after preliminary study made by special committees formed by the council.

(6) That the council executes the adopted research projects either in its own laboratories or in co-operation with other competent scientific institutions.

(7) That a national scientific documentation centre be established in each Member State, with the aid of Unesco if necessary and on request, which will be attached to the council and charged with providing scientists with the necessary scientific information.

(8) That the Member States undertake adequate training of scientists necessary to the country by strengthening faculties, universities and institutions, and by establishing new ones as well as missions abroad.

(9) That the Member States define and establish the appropriate status of scientific workers together with provision of the material conditions corresponding to the highest scale existing in the country.

(10) That the Member States give attention to the training and improvement of material and moral conditions of auxiliary and technical personnel of laboratories.

(11) That the public and private resources grant housing and financial assistance to universities and institutions of scientific research to enable them to undertake the execution of their projects as is done at present in other countries.

It is recommended to the Member States that such grants are exempted from all taxes.

(12) That the council has a duty to promote regional and international co-operation, to elaborate the scientific parts of bilateral and international cultural agreements and to represent the country in international scientific non-governmental organizations.

(13) That the Member States grant sufficient means for the exchange of their professors and scientific workers and request Unesco to anticipate in its budget for 1963–64 a supplementary provision to accomplish this aim.

(14) That the Member States promote organization of national or regional scientific congresses and symposia as well as participation in international meetings.

(15) That the Member States support their scientific institutions in co-operation with similar establishments in other countries to solve problems of regional or international importance.

(16) That Unesco should continue to promote the organization of symposia and regional scientific meetings to discuss subjects of interest to various Member States.

(17) That all efforts and results reached by science should be used solely to help humanity and to improve the standard of living of the peoples.

(18) The conference thanks the Middle East Science Co-operation Office of Unesco, the Science Council of the United Arab Republic as well as the international consultants, and recommends that Unesco should organize within two years a similar conference to study the progress made in the field of scientific research in the Member States.

ELECTRICAL ENGINEERING IN THE ROYAL NAVY

At almost the same time as he relinquished, by retirement, the post of director of electrical engineering at the Admiralty, Sir Hamish Maclaren assumed office as president of the Institution of Electrical Engineers. This is only the second occasion on which the chief electrical engineer of the Admiralty has occupied the presidential chair of the Institution. C. H. Wordingham, who became head of the Electrical Engineering Department of the Admiralty in 1903, was president of the Institution during 1916–18.

Very appropriately, in his presidential address delivered on October 6, Sir Hamish reviewed the development of electrical engineering in the Royal Navy. The electronic equipment and control gear of the submarine utilizing nuclear propulsion plant represents the culmination of some ninety years of development of the applications of electricity in naval vessels, the first being the electrical firing of guns. It was, however, nearly twenty years earlier that the Admiralty made its earliest uses of electrical signalling when in 1852 the twenty-two semaphore stations between Plymouth and Whitehall were replaced by an electric telegraph.

The first dynamo was installed in a warship in 1875 to provide power for a searchlight to be used against torpedo craft, and it is probably this early association with torpedoes that established the practice of placing the responsibility for all electrical equipment in ships on the torpedo officer. This practice remained in force until 1946 when the electrical branch was founded.

A combined ship lighting and searchlight installation was fitted in H.M.S. *Inflexible* in 1881, Swan incandescent lamps being connected in groups in series. By 1886 first-class ships were being equipped with three dynamos each supplying 200 amp. at 80 V.

The ring-main system of distribution at 22-V. direct current was introduced in the early years of the present century and remained the standard naval practice until after the end of the Second World War.

It was in 1896 that the remarkable pioneering experiments in wireless telegraph communication between ships were made by Captain H. B. Jackson. Communication was established between H.M.S.'s *Defiance* and *Scourge* over a range of 5,800 yards. In 1899 Marconi equipment with a range of up to seventy miles was installed in four ships.

Experience during action in the First World War focused attention on the impracticability of maintaining so-called watertight enclosures watertight, and means were devised for isolating, automatically, flooded equipment from the supply.

After the War the Admiralty reviewed the experience, to date, of electricity supply in warships and in particular considered the possible introduction of alternating current. Considerable importance, perhaps an undue amount, was attached to the ease and convenience of speed variation of the direct current motor and direct current was retained.

The application of electricity in fire control systems was greatly advanced during the First World War. Individual components such as plotting tables, data transmission and communication instruments had, however, been developed largely by individual specialist firms, giving rise to diversity of design and practice.

It was towards the end of the First World War that the gun director system was introduced in which a gyroscope was employed as a stable reference to ensure that the guns fired only when the ship was in a horizontal position during rolling. This was a prelude to the day when directors and gun mountings would themselves be stabilized.

Between the two World Wars action was taken towards achieving uniformity of practice in instrumentation. Much effort was directed towards the design of fire control computers, and, as the importance of air attack increased, to the special problems associated with the control of high-angle anti-aircraft guns. Of the work done at the Admiralty Research Laboratory during that period mention should be made of the plotting table which automatically records the ship's position on a chart, of the 'magslip', a data-transmission unit of much greater accuracy than any other available at that time, and of an electrically controlled oil-operated remote-power system for searchlights.

The outbreak of the Second World War produced immediately the problem of combating the novel and ingenious devices which had been developed by the enemy. The first was the magnetic mine. Real success in sweeping the magnetic mine was achieved with the development of the towed buoyant-cable sweep whereby a relatively large magnetic field is produced in the sea by circulating current pulses of

several thousand amperes round the loop of buoyant cable.

The degaussing of ships, at first effected by a single-turn coil embracing the hull, was, after considerable research, shown to be practicable with multi-core cable fitted inside the hull.

H.M.S. *Belfast*, damaged by a magnetic mine explosion in October 1939, exhibited extensive damage to electrical equipment from underwater shock. The shock accelerations and displacements resulting from non-contact under-water explosions were of a much higher order than those against which the equipment had been designed, and an extensive programme of experiment and of redesign of electrical equipment and of shock-proof mountings was undertaken.

The loss of the *Ark Royal* in November 1941 brought to light further important factors in the vulnerability of the electrical systems of warships. A hit by a single torpedo had the disastrous result of flooding one boiler room and the main switchboard room. The remote control of circuit breakers from the main switchboard was based on a system which the flooding rendered completely inoperative and services could not be restored although power was available for some time. Even the power supply was dependent, as the generators were driven by steam turbines, on the ship's main boilers. The redesign of the control system introduced relay control, energized from independent local supplies, and auxiliary diesel generators were provided.

Electrical actuation in the training and elevation of anti-aircraft guns was initiated in 1939, utilizing the rotating amplifier machine known as the 'metadyne', controlled by a magslip-data transmission system to which reference has already been made.

The introduction of radar for range-finding produced automatic following of the radar aerial so that the aerial, the gun director and hence the gun automatically followed the target. Fully automatic following of the target was achieved by designing the radar to provide its own misalignment signal and feeding the necessary additional information from the fire control computer and the stabilizer.

The action information centre has become the most concentrated part of the electrical installation of a warship. It is the focal point for radar and asdic information, for external and internal communication, aircraft and weapon direction and for navigation.

Alternating current was adopted in 1948 for all ships larger than mine-sweepers. Simplicity, reliability and the necessity to save space and weight in the large and complex electrical systems required made the advantages of alternating current supply overwhelming.

A supply frequency of 60 c./s. was adopted for the 440 V. three-phase system. The higher frequency of 60 c./s., in place of the standard power frequency of 50 c./s., had the great merit of a substantial reduction in the size and weight of machines and a higher maximum speed of 1,800 revolutions per minute. There was the added advantage of a common standard with the U.S. Navy. There is, of course, the disadvantage of more complex equipment where continuous variation of speed is required. Automatic voltage regulation is required, and a standard type of automatic voltage regulator utilizing a magnetic amplifier has been developed which can be used with generators of 150-kW.–1,500-kW. capacity.

Nuclear propulsion has revolutionized the performance of the submarine, which becomes at last a true submarine rather than just a submersible vessel. The nuclear submarine must, however, still have a battery for starting up and emergency standby although of smaller size than that for the conventional submarine. Because of the possibility of prolonged submerged operation, some of the battery problems encountered with conventional submarines became of even greater importance. The evolution of hydrogen on open circuit can be reduced by the use of grid alloys having a very low antimony content. Antimony-free grids would at the same time eliminate the production of the highly toxic gas, antimony trihydride, or stibine.

The electrical installation of the nuclear submarine is in fact much like that of the surface vessel with the addition of an electric drive of small power for emergency use. As in the surface vessel, an increasing amount of electronic and servo equipment is required, and there is in addition the equipment for reactor control and instrumentation. It is in the submarine, because of the acute limitation of space, that semiconductor devices offer special promise in their future application.

J. GREIG

POWDER METALLURGY

AN international conference on "Powder Metallurgy", sponsored by the Metal Powder Industries Federation and the Metallurgical Society of the American Institute of Mining and Metallurgical Engineers, was held in New York during June 13–17. At sessions throughout the first three days, papers were presented by authors and briefly discussed. Visits to plants were made during the last two days. The meetings were well managed and held to a precise time schedule which allowed little time for informal discussion. The hall, with a seating capacity of about four hundred, was filled for every session.

Dr. P. Schwarzkopf, honorary chairman of the conference, opened it with a review of a half-century of modern powder metallurgy, which he considers to have developed since Coolidge's paper of 1910 on the powder metallurgy of tungsten. He regards earlier powder metallurgy, such as that in pre-history, that by the Incas, and the British and Russian work on platinum, as detached from the development of modern technology to which they made little contribution. Powder metallurgy was a forgotten art at the start of this century, although in 1898 Welsbach patented its use to make osmium filaments. Coolidge's tungsten filaments were the first really usable product of modern powder metallurgy. Cemented carbides manufactured by powder methods came in 1922.

Work on the nature of the sintering process appeared in 1922 when Sauerwald published his first paper on the subject, which he thought of as a recrystallization process. Important later work on the theory of sintering included Russian papers published in 1945 and the work of S. P. Slater and G. C. Kuczynski. In recent times the latter worker has dominated thinking in this field.

Several papers at this conference made it clear that work on the theory of sintering is once again coming to life. It is now appreciated that we must not seek one dominant sintering mechanism for all materials, or even for one material at all stages of the sintering process, or in all circumstances in which sintering takes place. Kuczynski (University of Notre Dame) emphasized this by stressing the convenience of considering separately the two extreme stages of sintering when seeking to explain what occurs: these are: (1) the formation of necks between particles at the start of sintering, and (2) the disappearance of isolated pores towards the end of the process. The first stage is now fairly well understood, but the second is more complex and difficult to cope with. Unbalanced forces in the necks lead to flow of material in a viscous or plastic manner. He has shown that, if x is the diameter of the neck between sintering particles, and a the diameter of the particles, x^n/a^m is a function of time and the values of n and m are characteristic of the sintering mechanism which is operating:

$n =$	2	3	5	7
$m = 1$	Viscous or plastic flow	Evaporation and condensation	—	—
2	—	—	Volume diffusion	—
3	—	—	—	Surface diffusion

Recent observations of the sintering of copper wires twisted together show that volume diffusion is in this case the main mechanism. Kingery has shown it to be evaporation and condensation in sodium chloride. In glass it is viscous flow. Sintering of nickel at 1,400° C. is due to volume diffusion and that of iron at 850° to surface diffusion. Kuczynski described a very pleasing experiment on the sintering of copper-8 per cent indium. Indium diffuses more rapidly than copper in this alloy and where its concentration rises an indium-rich δ-phase forms. This phase was found in the necks between sintering particles, an observation confirming that diffusion is a mechanism of the sintering in this case.

The importance of grain boundaries is not yet clear. A. L. Pranatis and L. L. Seigle examined the sintering of iron, copper and nickel and observed the radius of the neck between particles to be proportional to time whether boundaries were present or not. However, they found that reduction did not occur in the volume of isolated voids in nickel at 1,400° C. unless boundaries ran into them, whereas B. H. Alexander and R. W. Baluffi observed shrinkage of voids within metal single crystals.

A few years ago M. Eudier reported that additions of hydrogen chloride to the sintering atmosphere accelerated the sintering of iron powder and improved the properties of the product. More recently J. Vacek described the spectacular effect of a trace of nickel in causing tungsten to sinter at half the temperature required for pure metal. Considerable interest was shown in such activated sintering, the practical significance of which is clear. That the nature of the sintering atmosphere may determine which sintering mechanism dominates a particular case was illustrated by Kuczynski's observation that single crystal particles of alumina sinter by volume diffusion when heated in helium containing a little oxygen, but by viscous flow in dry hydrogen.

J. Wulff (Massachusetts Institute of Technology, Cambridge, Mass.) has studied the effect of nickel on the sintering of tungsten. He reminded the conference that this remarkable effect was known to von Bolton long ago, but has been overlooked until very recently. Wulff found that additions of nickel are increasingly beneficial so long as a monatomic layer over the tungsten particles is being built up, but not after sufficient metal for this is present. He attributes the effect to diffusion of tungsten through the nickel. F. Eisenkolb (Technische Hochschule, Dresden) found additions of about 2 per cent of calcium fluoride to iron or steel powder to improve its sintered strength, but that larger additions reduced this.

It would be very interesting to know what effect these additions have on the Kuczynski coefficients of the sintering metal.

Kuczynski recalled attention to phenomena when two metals sinter together. Thus when copper and nickel are in contact at 1,020° C. the copper particles shrink and pits form in them near junctions with nickel, while the nickel particles expand. This is explained by the more rapid diffusion of copper than of nickel.

G. A. Geach and A. A. Woolf (Associated Electrical Industries, England) have examined a number of pure crystalline organic materials of widely differing molecular shapes and found that these did not sinter at 0·8 of the absolute melting points, although they show creep deformation at lower temperatures. It is not clear whether this should be attributed to an absence of self-diffusion of large molecules or to the low surface energy of such materials. Although nylon sinters it is interesting that it does so more slowly if the threads are stretched so that the material becomes more crystalline. It was reported that in commercial practice amorphous precipitated nylon is found to sinter more effectively than ground material.

Developments were reported in many techniques of powder metallurgy. Although hydrostatic pressing of powder in a rubber sack was patented in 1913 much attention is now being given to this method. H. H. Hirsch and C. E. van Buren (General Electric Co.) reported that pressing vessels up to 20 in. in diameter and several feet long now exist, and that pressures up to 50 t.s.i. can be used, although it is now known that for each material there is a pressure above which little advantage is gained (30 t.s.i. for tungsten, 4·5 t.s.i. for alumina). Isostatic pressing to finished form in shaped moulds of rubber or reversible gel is extending, and may lead to economy when only moderate numbers of parts are required. Slip casting of metal powders in porous moulds is also being developed, and A. Foster (Sylvania Electric Products) described freezing the mould at 29° F. to remove the casting safely, and then drying it for two days in fuller's earth because rapid drying damages the surface. Hot extrusion of metal powder is particularly valuable when pyrophoric powders, or those involving a health hazard, are pressed while in a closed can. Developments in the direct rolling of metal powder to strip which were described included the use of heated rolls. Rolls of very large diameter are desirable for compacting powders, and an interesting technique described used two rings of large diameter of metal which were threaded about the 8-in. rolls of a smaller mill and operated as large rolls.

The use of an explosion to drive the ram of a mould pressing powders will give pressures of 10^6 p.s.i. for microseconds: R. A. Cooley (Propellex Division, Chromalloy Corp.) reported improved properties of products pressed in this way. A remarkable result

claimed is nickel of density one per cent higher than the crystallographic value.

A large amount of work on dispersion-hardened materials was reported, and at present interest is greatest in materials based on aluminium, copper or nickel. It appears that the dispersed phase should be hard and that interfacial energy between it and the matrix should be low: thus thoria particles in titanium alloys have little effect unless the alloys wet the particles. Dispersed particles should be of irregular shape, not rounded, for greatest effect. F. V. Lenel and G. S. Ansell (Rensselaer Polytechnic) stated that the yield stress of these materials is determined by the stress which fractures a dispersed particle, and that it is inversely proportional to the square root of the spacing between particles.

SAP alloys (aluminium strengthened by dispersed oxide) are now known which can be rolled either hot or cold or which can be drawn and pressure-welded.

M. Eudier (Metallurgie Française des Poudres) reported that a controlled oxidation of nickel before sintering raises the density achieved, and he explained that the effect is due to filling of certain pores with oxide and later reduction of this without re-formation of cavities.

The powder metallurgy industry is expanding rapidly. The use of iron powder showed an upsurge during 1954–55, and in 1960 was three times that in 1956. Application of powder methods to beryllium is now important, and the plant to handle a large amount exists. Consolidation of powder in cans by quick blow-forging is important and disks 12 in. in diameter by 1·5 in. thick are made in this way. Beryllium foam made from fine powder, and the production by hot pressing of metal beryllide parts which have high thermal conductivity, are novel developments. Very large pieces can now be manufactured by powder methods: F. Emley (Westinghouse Electric Corp.) noted equipment for hot-pressing beryllium billets up to 60-in. diameter, and the production of molybdenum billets 40 in. × 3·5 in. × 3·5 in.

G. A. Geach

SOIL FAUNA IN RELATION TO SOIL FORMATION AND FERTILITY

THE study of soils has for long been the province of pedologists, chemists and microbiologists, and, apart from isolated instances, it has only been during the past fifteen years or so that the subject has attracted attention from zoologists in Britain. During the 1955 Easter School held by the School of Agriculture, University of Nottingham, many soil zoologists from Europe as well as Britain were brought together. This was succeeded during 1958 by a three-day international colloquium held at Rothamsted Experimental Station and devoted to "Progress in Soil Zoology". These have given new stimulus to the subject, and the recent symposium on "Soil Fauna in Relation to Soil Formation and Fertility", held by the Association of Applied Biologists, indicates the still growing interest which soil zoology is arousing. This symposium was held on October 14 at the British Museum (Natural History), where the new lecture theatre is eminently suitable for such meetings.

The theme was introduced and summarized by G. V. Jacks, director of the Commonwealth Bureau of Soils. He started by giving numerical evidence of the increasing number of publications on soil zoology appearing in *Soils and Fertilizers*: during 1937–40 there were three, during 1953–56 thirty, and during 1956–59 ninety. The part played by biological processes in determining soil fertility was then put in perspective. Under natural conditions soil animals are complementary to plants and necessary for operating the cycle of nutrients effectively. They are important factors in breaking down plant litter, mixing it with the soil and creating the porous texture characteristic of good soils.

The first paper was given by Dr. D. A. Osmond and Mr. P. Bullock, of the Soil Survey of England and Wales, on "Soil Fauna in Relation to Pedology". The condition of a soil is the result of many factors of which the fauna is but one. The influence of animals is difficult to assess in arable land, but may be very great in grassland and forest soils. Their effects range from the burrowing of mammals to the incorporation of quantities of plant material into the soil by the mesofauna. Dr. Osmond then described different soil-types with the aid of photographs of thin sections. Peat represents one end of the scale where plant matter is virtually unattacked by the fauna, and with increasing faunal influence one passes through moder and mull soils, finally culminating in the vermisols possibly found in parts of north England which are the result of intense earthworm activity.

The mechanics of earthworm influence were pursued by Dr. F. Raw, from Rothamsted Experimental Station, by a consideration of leaf burial in apple orchards. Comparisons were made between sprayed and unsprayed orchards, some under arable cultivation and others under grass. For sampling earthworm populations dilute formalin was found more efficient than permanganate, and in the seven orchards investigated six dominant species were found. Of these, pot experiments showed that only *Lumbricus terrestris* was responsible for pulling leaves into its burrows. Quantitative studies showed, moreover, a close relationship in the grass orchards between weight of *Lumbricus terrestris* populations and the percentage disappearance of leaf litter from cages. The rate of disappearance was inversely proportional to the amount of surface vegetation, being greatest in the arable orchards.

In grass orchards which had been sprayed with a copper fungicide for many years, the earthworm fauna was reduced to a single species living in the surface litter. Here leaf decomposition was very slow and the soil profile had typical mor characteristics.

Some aspects of work being carried out at the University College of North Wales, Bangor, were described by J. Hobart and A. J. Hayes. The former gave a paper on the distributional patterns of soil mites in pure and mixed stands of conifers. In the apparently uniform habitat of a Douglas fir plantation (*Pseudotsuga taxifolia* Britt.), only eight out of thirty-two common species of mites (adults) did not show a significantly aggregated distribution. Samples were taken along radiating transects from trees, and several species of mites were found to have very definite and different preferences for particular radial distances. These may be due to differences in the

thickness of the litter layer and in moisture content, and are evidence of very sensitive discrimination.

In mixed plantations, again, distinct populations were found in relation to spruce (*Picea* sp.), Scots pine (*Pinus sylvestris* L.), larch (*Larix* sp.) and silver fir (*Abies alba* Mill.). The numbers under spruce were generally lowest, and a few species showed definite preferences for larch or silver fir.

Hayes described some work on feeding behaviour of Oribatid mites using mainly *Hoploderma magnum*. Colonies were kept at constant temperature maintained at three different humidities and fed on weighed quantities of needles from three species of conifer. These needles were graded into three categories of age and condition. After 72 hr. the remains were re-weighed and the number of faecal pellets counted. Measurements were made on eight replicates of fifty individuals for each treatment. Production of faecal pellets for all three species appeared to be greatest for fallen but still entire needles and least for fresh green needles. Analysis of variance showed, however, that few of the differences between humidities, tree species or conditions of needles were significant. Preliminary results indicated that there was no correlation between loss in dry weight and the number of faecal pellets produced, and loss in dry weight of needles did not appear to give a satisfactory index of feeding.

As part of the concerted work on woodland soils by the Nature Conservancy at Merlewood Research Station, K. L. Bocock described some work concerned specifically with the comparative rates of disappearance of oak (*Quercus petraea* Liebl.) and ash (*Fraxinus excelsior* L.) leaves on contrasting sites. Weighed quantities of leaves were placed on the ground in nylon hair-nets and sampled periodically over 14 months. As a result of earthworm activity ash leaves on a mull soil disappeared most rapidly, with loss in nitrogen following closely the trends of loss in dry weight. On a moder soil the loss of nitrogen was relatively less rapid. Oak leaves on mull showed an actual increase in nitrogen content; possible explanations were the presence of nitrogen-fixing micro-organisms, absorption of nitrogen compounds from the rain or contamination with slime and droppings from soil animals.

Feeding experiments with *Glomeris* (Diplopoda) on hazel leaves (*Corylus avellana* L.) showed that the amount of water-soluble nitrogen was larger in the faeces than in the food, largely due to an increased ammonia content.

The symposium ended with a synoptic point of view of invertebrate metabolism and its effect on soil fertility. With the aid of diagrams, A. Macfadyen depicted the main paths of energy-flow in a typical grassland soil as a result of the direct metabolic effects of the fauna. Calories entering the system from sunlight pass through various levels (corresponding to successive links in food chains) at each of which some energy is dissipated in respiration. The proportions received and passed on by different groups of organisms and, in the case of agricultural exploitation of the grassland, the amount finally available to man were calculated.

Indirectly the fauna has catalytic effects on other organisms which are probably much more important: the feeding of animals on fungi eliminates senescent growths, effects the dispersal of spores and overcomes 'stasis', and their faeces provide food sources for other organisms. All such activities increase the rate of energy-flow which ultimately determines the soil fertility.

B. N. K. Davis

AGRICULTURAL HISTORY

THE joint winter conference of the Agricultural History Society and the Association of Agriculture was held on December 3, at the Institute of Education, University of London, under the chairmanship of Sir Keith Murray. Before lunch, Mr. Michael Havinden, research assistant, Museum of English Rural Life, read a paper on "Agricultural Progress in Open Field Oxfordshire". Modern research has suggested that the open field system was more flexible than was formerly believed. Mr. Havinden's researches among college documents and seventeenth-century Oxfordshire farmers' inventories has confirmed this still further. He is convinced that the introduction of improved rotations by agreement among the tenants or imposed by manorial lords was a major factor in delaying enclosure in Oxfordshire and possibly elsewhere. The improvement was mainly towards the introduction of fodder crops, the growing of more peas and beans and vetches, and the new legumes clover, sainfoin and lucern as well as some rye grass. In places a group of strips was enclosed by agreement and these crops were grown. He described the mechanism of this process very definitely. In other places fodder was grown and consumed by hitching the grazing animal on the strip. It has, of course, for long been known that sainfoin was grown on the chalk escarpment in the seventeenth century, but only vaguely. Mr. Havinden's researches have revealed places where this and other fodder crops were actually grown in the open fields, and he has thus made specific what was formerly only a general impression derived from remarks in the didactic treatises and propagandist literature of the time.

In the afternoon Mr. John Saville, senior lecturer in economic history, University of Hull, discussed "Public Opinion and Agricultural Depression, 1880–1900". He showed how the current difficulties of the landed interest had led reformers to demand the restoration of a peasant proprietary without any very clear perception of the methods by which the plan could be put into effect. Despite some ameliorative legislation, giving the farm worker the vote, the setting up of parish councils, some small-holding acts, etc., the ideas were in the main quite ineffective. These measures had been supported by liberal reformers in the first place, but afterwards received the backing of the great landlords, Henry Chaplin for example. In spite of that, somewhat less than 1,000 acres of small holdings were created before 1914.

The programme was closed by the showing of a film made by Imperial Chemical Industries in 1942, "The Harvest Shall Come", which is a moving history of the wretched conditions of employment in agriculture before 1914, the comparative prosperity of the workers during the two Wars, and their submersion in poverty in the interval between them, conditions that will never again be imposed.

PROGRESS IN BRITISH BROADCASTING

THE annual report and statement of accounts of the British Broadcasting Corporation for the year ended March 31, 1960, comprises a general review of the year, the reports of the Broadcasting Councils for Scotland and for Wales, chapters on programme output, regional broadcasting, audience research, external broadcasting, engineering, staff and contractual matters, publications and finance, together with a series of appendixes and tables*. Matter of scientific interest is contained mainly in the general review and in that on engineering. The general review notes that plans are ready for substantial advances in sound broadcasting, which shows every sign of maintaining a hold on the public in its own right and as a service complementary to that of television. In the overseas and international spheres, further developments and possibilities lie ahead for the Corporation, especially in the field of television, and, generally, the Corporation considers that it has gone a considerable way to map out the courses that it should follow and the programme of development that will be needed during the next five to ten years.

The Corporation welcomes the Government's decision that during 1961–62 the full net proceeds of the licence revenue, apart from the £1 excise duty, should be devoted to broadcasting. However, the retention by the Treasury of 5 per cent of this revenue in the current financial year has necessitated the slowing down or postponement beyond 1960–62 of some projects which the Corporation regards as highly desirable, and which it wishes to complete at the earliest possible date. During the year the number of householders with combined licences for sound and television rose from 9,255,422 to 10,469,753, and that of those with licences for sound only decreased from 5,480,991 to 4,535,258. About 97 per cent of the population of the United Kingdom are now within range of the VHF sound broadcasting network, and it is estimated that rather more than one household in five has a VHF receiver. In sound, as in television, the Corporation is planning to provide or improve coverage in certain difficult areas by building low-power satellite stations, and schemes have also been prepared both for a further extension of coverage and also for introducing a system of local broadcasting on VHF. Audience research indicated that adult viewers with a choice of BBC and ITV were devoting some 37 per cent of their evening viewing time to BBC programmes in the last quarter of the year, compared with 32 per cent in the first quarter.

Experience gained during the past eleven years suggests that the restriction on broadcasting imposed by Section 63 of the Representation of the People Act, 1949, is now out of date, and the report expresses the hope that action will be taken to amend the Act accordingly. In science broadcasting, Prof. Medawar's Reith Lectures took an outstanding place, and upwards of 150 leading scientists took part in science programmes in sound radio during the year, while in television "Eye on Research", in which scientists in many fields demonstrate their equipment and research techniques and explain the work that they are doing, was the main continuing contribution. From time to time, however, the full resources of television are deployed on some major scientific theme, but the series of televised scientific demonstrations given by Sir Lawrence Bragg in the main lecture theatre of the Royal Institution were also highly appreciated by viewers. Preparations went forward throughout the year for the increase in output of the school television service to take place in the 1960–61 school year, and the scope of the service will also be extended to cover some of the special needs of primary schools and of the sixth forms of grammar schools.

Referring to regional broadcasting, the report expresses the view that if full advantage is taken of the opportunities for development, in adjustment to the changing needs of the time, regional activities in sound will form an enduring part of the overall pattern of the Corporation's broadcasting; but, while sharing fully the desire of the Broadcasting Council for Wales for an allocation of frequencies which would permit a separate television transmitter for South Wales, the Corporation has been unable to take the necessary steps because of the insufficiency of channels available. At present the Corporation's television service covers 98·8 per cent of the population of the United Kingdom, but the technical problems in bringing this to 100 per cent are formidable and are discussed in some detail in a special section of the review dealing with future tasks. The first of these is seen as the extension and improvement of transmitter coverage in areas where reception, whether of sound or television programmes, is unsatisfactory or non-existent. For television the only frequencies that could be readily applied for this purpose are the as yet uncommitted channels in Band III, and if the Government decides that these should be used for an additional television service, the Corporation wishes to provide the additional service. Apart from giving viewers a genuine alternative service, this second service would enable the Corporation to increase the number of serious, cultural and informative programmes, to cater more fully for regional needs, to extend educational broadcasts, and to provide more opportunity for experimental programmes. The Corporation believes that a move into Bands IV and V, which is an essential condition for a change in television standards, can be made successfully only if the public has the incentive of one or more new programmes in these bands. Given the necessary frequencies and finance, the Corporation would be prepared to start a new service in these bands and also if the Government so decided to start a service of colour television in Bands I or III, taking advantage of the experience it has already acquired and of the many experimental transmissions it has made in colour using the present 405-line standard. The Corporation claims that it could start a second television service in Band IV if it were granted the full proceeds of the present £4 licence, and that full development of the Corporation's ser-

* Annual Report and Accounts of the British Broadcasting Corporation, 1959–60. Pp. 175+8 plates. (Cmnd. 1174.) (London: H.M. Stationery Office, 1960.) 6s. net.

vices in sound and television, including a new television service in Bands IV and V and of colour, would call for a combined licence at about £5.

Under engineering research and development, the report notes that a comprehensive report has been prepared for publication on a series of experimental transmissions in Band V which included a comparison of the existing British 405-line standard and the Continental standard of 625-lines. The regular experimental stereophonic transmissions, commenced in 1958, have been continued, and the Corporation is investigating possible systems of broadcasting both stereophonic channels from a single VHF transmitter in such a way that monophonic reception is not impaired. Research continued into various aspects of videotape recording as well as investigation of the propagation properties of the ionosphere, for purposes of day-to-day operation of the Corporation's short-wave services, and considerable effort has been directed to the design of equipment using transistors instead of valves, although in broadcasting, and particularly in television, it is difficult to obtain the same high standard of performance from transistors as can be obtained from valves. Nevertheless, in almost all new portable or mobile audio-frequency equipment, and also in fixed equipment designed to operate independently of the public mains supply without large and costly batteries, it is possible and advantageous to use transistors.

While there is a marked potential audience for the Corporation's external broadcasts, to which the development of transistor receivers, cheap and easy to run, has made an important contribution, especially for medium-wave transmissions, Communist China has now displaced the BBC as the third largest external broadcaster. The services have been extended in certain directions, but rising costs and the stringent limitation of grants by the Government have offset the expansions by reductions elsewhere, and the report stresses the challenge which faces external broadcasting from the United Kingdom. In meeting it, the Corporation's international reputation for reliability and independence, its long experience and its established position as a source of programmes regularly heard and re-broadcast throughout the world are solid advantages, but they require ample technical support, particularly by way of higher-powered transmitting stations in the United Kingdom and more relay stations overseas. When this is forthcoming, the BBC will be able to take greater advantage of the many opportunities for presenting Britain to the world through this medium.

SCIENTIFIC RESEARCH IN NEW ZEALAND

THE report of the Department of Scientific and Industrial Research, New Zealand, for the year ended March 31, 1960, shows gross expenditure of £1,812,000, and staff at April 1, 1960, totalling 1,121, including 401 professional, compared with 1,067 and 390, respectively, in the previous year*. It includes the Minister's statement, the report of the Council for Scientific and Industrial Research, the Secretary's report, notes on the work of the several branches and divisions as well as of the incorporated research associations and on grant-aided research in other institutions, and also lists of publications. The second annual report of the Ross Dependency Research Committee is appended, to which also is attached a list of publications. A survey of the work of the Department made by the Council during the past two years led to the conclusion that in most branches the balance was held between *ad hoc* and long-term basic research, though in a few units basic research could with advantage be strengthened. Over the past decade the number of scientific staff employed by the Department has remained virtually static and there is virtually no scope for readjustments to meet the demands of new developments in nuclear science, oceanography, geothermal or Antarctic activities. Limitations of staff and finance debar the Department from exploiting fully the scientific opportunities to assist primary and manufacturing industry, and the Council estimates that full implementation of the present programme of work requires an increase of 40–50 staff per annum and of expenditure from £1,812,000 in 1959–60 to £2,090,000 in 1960–61, £2,133,000 in 1962–63 and £2,265,000 in 1964–65, assuming that costs and salary scales remain at the 1959 level. Provision of £200,000 per annum for buildings over the next five years is also recommended, apart from the cost of some major items of equipment such as a small nuclear reactor and electronic computer. Establishment of a National Research Organization as an independent organization responsible for the main research functions of Government is recommended as likely to lead to greater efficiency, better co-ordination in existing research programmes and greater flexibility in meeting future needs, and finally the urgent need for a thorough revision of professional salaries is emphasized.

Since 1949–50 the expenditure of the Department has risen from £959,000 to £1,658,000 in 1958–59, and was only 0·146 per cent of the gross national product, compared with 0·173 per cent, and the professional staff numbered 383 compared with 363. Research grants to universities, research institutions, etc., in 1959–60 totalled £172,272, but the only branches of the Department in which expenditure exceeded £100,000 were the Dominion Laboratory (£194,180), Dominion Physical Laboratory (£199,203), Geological Survey (£102,750), Geophysics Division (£111,206), Grasslands Division (£108,078) and Soil Bureau (£105,512).

The Secretary's report refers briefly to some of the research work of the year. An extensive programme of tests on the durability of paints showed that poor workmanship and inferior quality of paint were the prime causes of poor durability, with excessive weathering of priming coats and the dip-treatment methods of timber preservation as contributory factors. More careful attention to surface preparation is required when using synthetic finishes. Use of sawdust or shavings from arsenic-treated timber in smoke curing has been shown to constitute a toxicity hazard through deposition of arsenic on the food. The analysis of steel and reinforced-concrete frame structures is being continued, and the use of an analogue computer offers a

* New Zealand. Report of the Department of Scientific and Industrial Research for the year ended 31 March, 1960. Pp. 128. (H. 34.) (Wellington: Government Printer, 1960.) 4*s.* 6*d.*

big advance on the traditional technique of applying a static seismic coefficient. The computer is being modified to allow for multi-storey yield.

A major addition to the equipment used in the auroral programme has been the auroral radar set up at Arrival Heights close to Scott Base, and the unmanned automatic observatory operating for a year near Becks in Central Otago has demonstrated the superiority of conditions there for all aspects of the optical work. The Geophysical Observatory has made a special investigation of the New Zealand ionospheric data to meet requests made by the Post and Telegraph Department, and a detailed magnetic survey was made on the aircraft compass-swinging site at Wellington Airport; this was to ensure that the area was free from magnetic effects due to buried ferro-magnetic materials that might affect aircraft compasses. Considerable attention has been directed to modern map-preparation techniques and procedures in cartography, and a major activity of the Antarctic programme has been the continuation of the geological and topographical survey of the Ross Dependency begun by parties from the trans-Antarctic Expedition. A major step forward in pollen research in New Zealand will be the publication this year of a *Geological Survey Palaeontological Bulletin* recording the important results of a new phase of the work—the successful extraction of pollen from marine sedimentary rocks.

In the past year the New Zealand benthic survey has concentrated on the west coast of the North Island and the western approaches to Cook Strait, and the survey is also building up collections of marine bottom fauna from which the common New Zealand species, and many of the rarer ones can be identified and described. Work on the design of a gas-pressure alarm system in telephone cables led to a method of calculating the required shapes of the pressure waves for a cable of given permeability to the gas for any size of puncture. At the Dominion Physical Laboratory the internodal cell of the alga *Nitella* is being used for an investigation of cell wall growth. Work has been carried out on the growth of *Pittomyces chartarum* on various synthetic media, and on the influence of different factors on the production of spores, while the fatty acid composition of this and related species has been determined and a systematic investigation made of the anti-fungal substances in sweet vernal and red clover.

Much of the development programme at the Keikohe sub-station of the Grasslands Division has been concerned with the typical heavy clay 'gumland', which is very acid, extremely low in plant foods and has a typical 'gumland' cover of stunted manuka and rushes. Heavy dressings of lime, phosphate and potash at the time of sowing gave spectacular results. Work on the South Island tussock grasslands has revealed two undescribed and widespread grassland associations of botanical and economic importance. Two high-yielding varieties of potato have been bred which appear to combine resistance to wind and drought with resistance to late blight, and use of systemic insecticides has opened up possibilities of producing better seed potatoes in areas such as Lincoln, where aphid numbers are high for only short periods. By use of stickers and cultures with a high bacterial count, nodule bacteria have been held on lucerne seed in a viable condition for at least four weeks, while work on scale insects on apples indicates that shelter belts of *Pinus radiata* are the cause of the trouble. Factors governing the need for potash top-dressing on New Zealand soils are also being studied as well as pruning systems for apples, the storage of apples in controlled atmospheres, the control of *Verticillium* wilt of tobacco and the general ecology of rabbits, while a survey at Lake Monk, Southern Fiordland, has contributed towards the understanding of the relations which have arisen between introduced animals and native forests.

THE DELHI ENGINEERING COLLEGE TRUST

At a meeting of the sponsors of the Delhi Engineering College Trust, held at Bowater House on November 16, the chairman, Sir William McFadzean, president of the Federation of British Industries, reviewed progress in the setting up of the College, in which H.M. Government, the Government of India and British industry are working together with the aim of establishing an outstanding institution for technical education.

Since January 1959, when Prince Philip laid the foundation stone of the College at Delhi, the Government of India has completed the administrative organization and has set up a governing body of which the chairman is Prof. M. S. Thacker, Permanent Secretary of the Indian Ministry of Scientific Research and Cultural Affairs. All preparations are in hand for the opening of the College during July 1961, on the magnificent Haus Kas site near Delhi.

The United Kingdom Government has undertaken to provide ten British professors for the College, who will advise the Indian professorial staff during the first five years. Four professors are already at Delhi, and three more are to be appointed this year.

Sir William also reported the success of the appeal to British industry for subscriptions to provide equipment for the College. The target figure of a quarter of a million pounds had been exceeded, thanks to 115 companies which had contributed over the past year. Over the next three years, as the buildings of the College are completed, the equipment for the successive stages of the five-year course is to be purchased on behalf of the Trust by the Crown Agents for Oversea Governments and Administrations.

Sir William then outlined the desirability, after the College was established, of offering continuing academic and practical support for it from the United Kingdom Government, British industry, and British universities and colleges. This was a matter to which the sponsors would be invited to give further attention when the time was ripe. In the meantime, the progress that was being made in all preparations for the opening of the College held out good promise for its future as a centre of advanced education in engineering in India.

Sir Eric Coates, chairman of the Executive Committee of the Trust, described how the most modern equipment for the College was being selected, in accordance with the advice of an academic working party under the chairmanship of Prof. S. R. Sparkes, of the Imperial College of Science and Technology; and

how other aspects of the project were developing in accordance with the programme of the Indian Government.

Sir Willis Jackson, as chairman of the Technical Sub-Committee of the Trust, referred to the difficulties at the present time of finding the right calibre of man for professorial posts. He emphasized the need for further help by British industry, perhaps by endowing chairs at the College, and also by facilitating the secondment of experts in specialist fields of technology for short periods to assist in the conduct of postgraduate courses and in stimulating research.

Sir Algernon Rombold, Deputy Under-Secretary of State, Commonwealth Relations Office, said that satisfaction at the response to the sponsors' appeal would be widely shared, and that the project was an outstanding example of co-operation between the Governments of India and the United Kingdom and British industry. He endorsed the hope that a recognized system of secondment by industry and universities would be developed to meet the growing need for experts for overseas service.

Sir Alexander Fleck said that the vigour of the work of the Trust's officers showed that the special problems presented by any tripartite project of this nature were being solved in a satisfactory way. He believed that the continued support of British industry would be readily forthcoming for the project on the lines which Sir William McFadzean had sketched out. This would be true both in the immediate future and over the years as the project developed.

Among the other sponsors present were Sir Hugh Beaver, Sir Leslie Gamage, Mr. S. E. Goodall, Sir Kenneth Hague, Sir Harry Jephcott, Prof. Sutton Pippard and Mr. Whitney Straight. Other sponsors who were unable to attend were represented.

THE ROBERTSON CREEK SPAWNING CHANNEL

MUCH of a recent issue of the *Canadian Fish Culturist* (No. 27, 1960) is given up to accounts by K. C. Lucas and D. Mackinnon of a man-made spawning channel which has just been built by the Fish Culture Development Branch of the Department of Fisheries of Canada in Robertson Creek. This is a secondary outlet of Great Central Lake, which lies near Port Alberni on Vancouver Island, British Columbia.

The design of this new artificial spawning channel is based on the experience gained in the construction and operation of an artificial spawning channel on Jones Creek, near Hope, British Columbia, which was made in 1954. The Jones Creek channel was constructed to save the salmon stocks in a stream threatened by the diversion of the flow because of hydro-electric development, but the Robertson Creek channel is the first such channel to be built primarily as a fisheries development project. Robertson Creek is an exceptionally favourable area for such a project, because works for the complete control of flows already existed, no provision for flood-flows was necessary, silting of the spawning beds by the incoming water seemed unlikely, the temperature of the stream remained moderate and the area was readily accessible.

The total length of Robertson Creek is 4,200 ft., and 2,550 ft. have been developed as a spawning channel. The gradient of the natural stream bed was greater than that needed for the spawning channel, so four drop-structures have been provided to localize the unwanted drop. Near the head of the spawning channel and a short distance below Great Central Lake is a downstream migrant diversion structure, which allows migrants passing out of Great Central Lake to be diverted into a flume which runs alongside the spawning channel to enter the latter just below drop structure 3. If it were found necessary in the future, this diversion flume could be extended downstream so as to bypass the lower spawning area. The first three drop-structures downstream from the diversion structure are similar in design and are relatively simple structures. Inclined plane traps are provided at each so that downstream migrants can be counted, and each incorporates a pool and weir-type fishway to provide for the upstream movements of adults if desired. The lowermost drop-structure (4) is larger and more complex, because it incorporates a fish holding and collection system, and there is an observation chamber built into the side of the fishway.

A number of rearing ponds have been built at one side of the channel near its upper end, and these have been specially designed to allow maximum flexibility. Another additional structure is of particular interest; this is an experimental test-flume, approximately 150 ft. long and 30 ft. wide, which lies in the channel a short distance below drop structure 3. Plans were made to construct this flume before it was decided to make the channel, and the Fisheries Research Board of Canada has contributed to its cost. This flume will be used for tests of fry and smolt guiding devices and for fundamental work on the physiology of adult salmon.

Previous work on the survival of Pacific salmon eggs and alevins has shown that the percentage survival varies widely, but is usually low (less than 10 per cent). The results of the first transplant of pink salmon eggs in the Robertson Creek spawning channel are therefore particularly encouraging. More than one and a half million pink salmon were planted, at the eyed stage, during the latter half of November and the first days of December 1959. The first fry was trapped on March 15, 1960, but nearly all the fry migrated during the first three weeks of April and, when the last batch recorded migrated, during the night of April 21–22, the total represented roughly 95 per cent of the eyed eggs planted.

This artificial spawning channel is clearly a very important site for experimental investigations of many aspects of the biology of various stages in the life-history of Pacific salmon. Judged as a piece of experimental equipment, it is not cheap. To date, more than £81,000 has been spent on the channel, the experimental flume and the small field camp which has been built near the lower end of the channel. It is becoming increasingly clear, however, that many problems of salmon biology cannot be solved unless adequate experimental facilities can be provided, and there is good reason to suppose, therefore, that this outlay will prove to be money well spent.

AN ATOMIC BEAM SPECTROPHOTOMETER

By G. R. ISAAK*

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THIS article describes an optical spectrometer of extremely high resolution which has been developed in these Laboratories during the past two years. It is similar in principle to recently described X-ray spectrometers based on the Mössbauer effect[1], but differs in that it is concerned with wave-lengths in (and near) the visible region of the spectrum.

The present instrument is based on the principle of scanning the spectral line under study by measuring the variation of intensity of transmitted light as the absorbing line is made to traverse the width of the emission line under investigation. Extremely narrow spectral lines of nearly natural line-width are obtained by using a highly collimated atomic beam[2,3] emitting, absorbing or scattering light at right angles (or nearly so) to the direction of motion of the atoms, thus reducing Doppler broadening.

This narrow spectral line can then be used (by the Zeeman, Doppler, Stark or modulation effects[4]) to scan the spectrum under study, and, from the variation of transmission (or resonant scattering) versus displacement, the wave-length of the centroid of the spectrum and its profile can be deduced.

The range of wave-lengths which can be scanned is restricted to the immediate vicinity of the resonance lines of the atoms composing the beam, although it may be possible to examine other than resonance lines by populating excited levels of atoms by resonance radiation or electron bombardment. In practice the Zeeman scan can cover a range of the order of $\pm$ 0·1 Å. for magnetic fields of 10,000 gauss. The range is usually very much smaller for scans relying on the Doppler shift, the Stark splitting or the modulation effect.

The resolution of the method is determined by the width of the spectral line used. If the resolution R is defined in terms of a criterion analogous to the Rayleigh criterion[4] we have $R = \lambda/\Delta\lambda$, where λ is the wave-length and $\Delta\lambda$ is the wave-length change of a perfectly monochromatic incident light-beam which will result in a 19 per cent change in absorption. Then the resolution R can reach 10^8 or more by collimating the atomic beam sufficiently to reduce the Doppler broadening, and it is ultimately limited by the natural line-width to a value $R = \lambda/\Delta\lambda = 4{\cdot}1\ c/\lambda\gamma$ using the Lorentzian line shape, where c is the velocity of light and γ is the total transition probability per unit time[5]. Thus for mercury, ideally for a single even isotope of mercury, for example, mercury-198, we would expect[6] $R_{max.} = 5 \times 10^8$ for the 2536·5 Å. spectral line.

Two sealed glass atomic beam units (Fig. 1) were constructed to demonstrate the high resolution attainable with the above method. Because of its convenience, sodium was used as a working substance although its D lines have a complex structure. A low pressure was maintained by a small titanium pump[7]. An electric oven was used to heat the sodium to 300° C. and two glass slits of dimensions 2 × 18 mm. spaced 10 cm. apart collimated the atomic beam, which entered an observation chamber and condensed on a surface cooled with liquid nitrogen. To avoid appreciable Zeeman splitting of the spectral lines by stray magnetic fields in the vicinity of the observation chamber, the pumping magnets were removed during measurements. A pressure of 10^{-6} mm. mercury or less could be maintained for several hours without the operation of the pump by using sodium purified by multiple distillations, and baking the glass unit for many hours before sealing off.

Two such units were arranged as shown in Fig. 2. The sodium vapour lamp L illuminated the atomic beam E of sodium (the emitter) shown in plan. A second atomic beam unit A, with the atoms moving parallel to those of the emitter E, could be used as a resonant absorber. Of the light scattered at right angles to the direction of the atomic beam E, a beam subtending a very small solid angle served as a source of nearly monochromatic light of known line profile. The shape of this spectral line was examined by measuring the intensity of the light transmitted, with the photomultiplier $D1$, as the absorber spectral line was moved across the emission line. The outputs of photomultiplier $D1$ and comparison photomultiplier $D2$, looking at the emitter only, were amplified in a difference amplifier and recorded on an XY recorder.

In the first experiment the practicability of Zeeman scanning was investigated by placing the absorber A in a magnetic field generated by a set of Helmholtz coils.

Light resonantly scattered by the emitter E passed through the absorber A parallel to the magnetic field

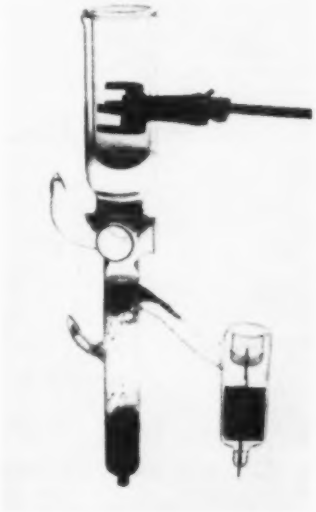

Fig. 1. A sodium atomic beam unit

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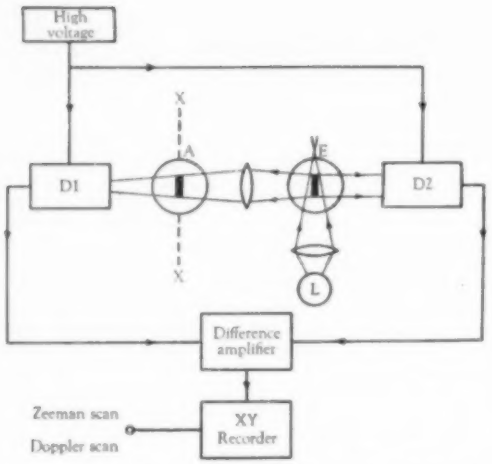

Fig. 2. Arrangement of apparatus for demonstration of high resolution of the method

and was detected by the magnetically screened photomultiplier $D1$ and recorded by the XY recorder as a function of the magnetic field by driving the X-axis with a voltage signal derived from the current through the Helmholtz coils. Electron-spin resonance in a small sample of $\alpha\alpha'$diphenyl picryl hydrazyl placed in a position normally occupied by the atomic beam was used to calibrate the linear magnetic field scale. Fig. 3 shows a typical Zeeman scan having a full width at half height of 67 gauss. This value is only slightly larger than the value calculated on the assumption that each hyperfine structure component of the emission and absorption lines of sodium has a fractional width of $3{\cdot}8 \times 10^{-8}$ (natural line-width $2{\cdot}1 \times 10^{-8}$ and residual Doppler-width $3{\cdot}1 \times 10^{-8}$), and each hyperfine structure component of the absorption line is split up in the weak magnetic field into a multiplet with an effective magnetogyric ratio of 0·55 Bohr magneton for the six components.

In a second experiment the feasibility of Doppler scanning was studied by slowly rotating the absorber atomic beam A about an axis X (Fig. 2) and recording the transmission as a function of inclination θ of one beam with respect to the other.

By rotating the absorber atomic beam through an angle θ the absorption line is displaced by an amount $\Delta\lambda = \lambda\bar{v}/c \sin\theta = \lambda\bar{v}/c\,\theta$ for small θ, where $\bar{v}$ is the mean velocity of the atoms in the beam. Consequently, a measurement of the transmission in the

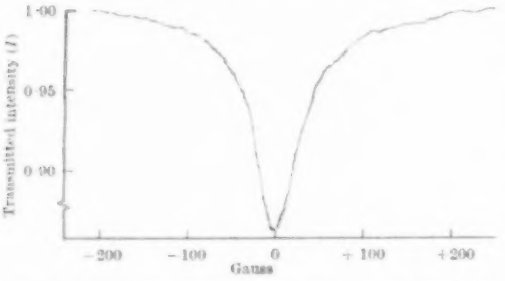

Fig. 3. Zeeman scan showing variation of transmitted intensity I with magnetic field applied to absorber A

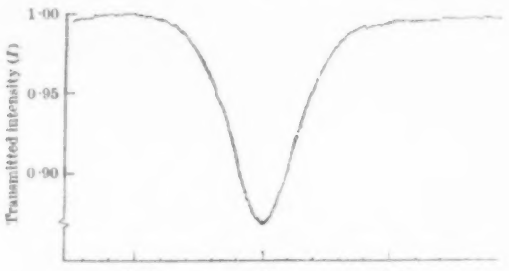

Fig. 4. Doppler scan showing variation of transmitted intensity I with inclination θ of absorber A with respect to emitter E; angular rotation through 1° corresponds to a wave-length change of 3×10^{-4} Å.

range $\pm\theta$ corresponds to a measurement of the overlap of the emission and absorption lines as the wave-length difference varies from $-\Delta\lambda$ to $+\Delta\lambda$.

Unfortunately such a rotation produces a broadening and asymmetry[8] of the spectral line in addition to the Doppler displacement.

Fig. 4 shows such a transmission profile with a full width of $\theta = 3{\cdot}0°$. Assuming a mean atomic beam velocity[9] of 870 m.sec.$^{-1}$, this corresponds to a fractional width of $\Delta\lambda/\lambda = 15 \times 10^{-8}$.

This value exceeds slightly a theoretical estimation, taking into account the natural line-width, the residual Doppler broadening, the inclination broadening and the broadening resulting from the overlap of the hyperfine structure components of the $D1$ and $D2$ lines of sodium.

From these results it was deduced that the components of the sodium D lines had widths of approximately $\Delta\lambda/\lambda = 4 \times 10^{-8}$ corresponding to a resolution of the order of 10^8, but because of the overlap of the hyperfine structure components the resolution was reduced by a factor of 2.

We can conclude that the above method can, in rather special circumstances, produce very high resolutions and can be used to study spectral line displacements, spectral line profiles and integrated areas under a spectral line. The resolution is highest and the interpretation of the results is simplest if the atoms in the beam have a simple spectral line, that is, have no nuclear spin and are identical.

Among the obvious applications is the study of isotope shifts. A particularly attractive case would be the study of isotope shifts of mercury using one beam of a separated isotope of zero nuclear spin, for example, mercury-198.

An atomic beam of sodium is being used as a high-resolution spectroheliograph for the study of the profiles of the Fraunhofer absorption lines.

I wish to thank Mr. R. A. Dewar and Dr. R. L. Martin for their interest and the Directors of Imperial Chemical Industries of Australia and New Zealand, Ltd., for permission to publish this material.

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INFLUENCE OF MOLECULAR STRUCTURE ON THE LIQUID/LIQUID EXTRACTION OF THE CHLORO-COMPLEXES OF GALLIUM AND INDIUM WITH ALIPHATIC ETHERS

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THE determination of elements of low abundance in geological materials is of considerable interest in geochemistry, and very sensitive methods have been developed in recent years for the estimation of these trace elements. Such techniques include neutron activation[1] and recent work on the combination of ion-exchange enrichment and spectrochemical analysis[2–5]. There is clearly a place for solvent extraction methods in the general scheme of analysis of elements of very low abundance, and this particular field seems to have been neglected in recent years.

An investigation has therefore been made into the extraction of gallium and indium (both elements of geochemical interest) from solutions of different concentrations of hydrochloric acid into a series of seven aliphatic ethers in an attempt to study more fully the factors involved in the extraction of these elements. (For reviews of general extraction procedures, see Irving[6], Martin and Holt[7] and Kitahara[8]).

Both indium and gallium are able to form ion-association complexes in the presence of hydrochloric acid, and in its very simplest form the mechanism is probably :

$$In^{3+} + 4\ Cl^- \rightleftharpoons InCl_4^- \quad (1)$$

$$InCl_4^- + H^+ \rightleftharpoons H^+, InCl_4^- \quad (2)$$

According to Bjerrum[9], the stability constant of the ion-pair formation (K) is dependent on the absolute temperature (t), the distance apart of the charge centres (d) and the dielectric constant of the solvent (ε). In a simplified form the Bjerrum equation may be represented as follows :

$$K = \frac{C}{d.\varepsilon.t.} \quad (3)$$

where C is another constant.

At constant temperature it is obvious that K will depend on d and ε, and part of the purpose of the present investigation was to attempt to establish the relative importance of these two factors.

If ion-association complexes only of the type shown in equation (2) were formed, then presumably the distance between the charge centres would always be constant and the extent of extraction into the ethereal phase would, at constant temperature, depend only on the dielectric constant of the solvent. However, oxonium solvents can play a special part in ion-association systems, since the basic character of the oxygen atom enables the solvent molecule to be incorporated in the co-ordination sphere of the metal[10]. We may therefore expect to have association complexes formed in the following manner :

$$In^{3+} + 6\ R_2O \rightleftharpoons In(R_2O)_6^{3+} \quad (4)$$

$$In(R_2O)_6^{3+} + 4\ Cl^- \rightleftharpoons In(R_2O)_2Cl_4^- + 4\ R_2O \quad (5)$$

$$In(R_2O)_2Cl_4^- + H^+ \rightleftharpoons H^+, In(R_2O)_2Cl_4^- \quad (6)$$

In this case it would appear that steric effects should play an appreciable part in determining the value of the stability constant of the complex, since they will to a large extent determine the value of the charge distance d. A study of the extractability of gallium and indium into a series of homologous ethers should clearly furnish valuable data about which mechanism is operative in the extraction of these metals, provided the dielectric constants of the solvents are also known.

Experimental Procedure

A stock solution was prepared containing 0·02 mgm. of indium and the same quantity of gallium per ml. 1-ml. aliquots of this solution were transferred to a set of 50-ml. test-tubes, and varying amounts of hydrochloric acid and water were added to each so that the final volume was 5 ml. and the final concentrations of hydrochloric acid were : N, 2 N, 3 N, 4 N, 6 N and 8 N, respectively. Five ml. of an aliphatic ether (pre-equilibrated with the appropriate strength of hydrochloric acid) were then added to each test-tube and the contents shaken for 3 min. The phases were then separated and transferred to 50-ml. porcelain basins. Twenty mgm. of sodium chloride were then added as a matrix and the samples were taken to dryness. The residues were then loaded into graphite electrodes and the indium and gallium determined spectrochemically, using the magnesium impurity in the sodium chloride as internal standard. The spectra (2750–4680 Å.) were recorded on Kodak 103-0 blue-sensitive plates. The spectral intensities

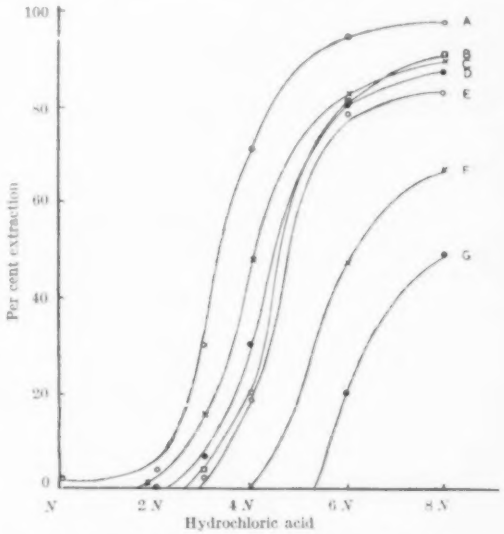

Fig. 1. Percentage extraction of gallium into aliphatic ethers from a range of concentrations of hydrochloric acid. *A*, ethyl ether ; *B*, methyl-hexyl ether ; *C*, ethyl-hexyl ether ; *D*, methyl-butyl ether ; *E*, *iso*propyl ether ; *F*, butyl ether ; *G*, amyl ether

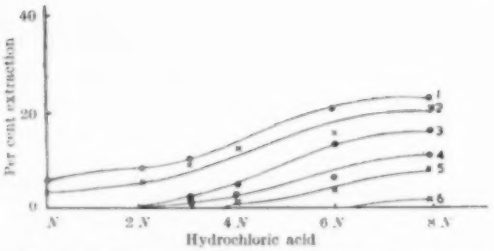

Fig. 2. Percentage extraction of indium into aliphatic ethers from a range of concentrations of hydrochloric acid. 1, ethyl ether; 2, methyl-hexyl ether; 3, ethyl-hexyl ether; 4, methyl-butyl ether; 5, *iso*propyl ether; 6, butyl ether

were measured and the percentage extraction hence determined.

The experiments were carried out on the following solvents: ethyl ether, *iso*propyl ether, butyl ether, amyl ether, methyl-butyl ether, ethyl-hexyl ether and methyl-hexyl ether. In every case the solvent was purified by distillation over sodium after removal of peroxides.

In Fig. 1 the percentage extraction of gallium is shown as a function of concentrations of hydrochloric acid for each of the seven ethers. The corresponding results for indium are shown in Fig. 2.

The dielectric constant for each ether was measured by the conventional condenser-resonance method[11], in which the sample is placed in a special cell between two silver electrodes and forms the dielectric of a condenser. A variable condenser is tuned to resonance with this system and the dielectric constants hence determined. These results are shown in Table 1.

Table 1. Dielectric Constants of Aliphatic Ethers at 20° C.

Solvent	Dielectric constant
Ethyl ether	4·33
Methyl-butyl ether	4·20
Ethyl-hexyl ether	4·05
*Iso*propyl ether	4·04
Methyl-hexyl ether	3·90
Butyl ether	3·08
Amyl ether	2·82

An examination of Figs. 1 and 2 shows that, far from increasing with decreasing dielectric constants, the extractability of the chloro-complexes of indium and gallium actually decreases, and indeed at 4 *N* hydrochloric acid a plot of percentage extraction of gallium as a function of dielectric constant shows an approximately linear relationship of positive slope. Since the influence of dielectric constant appears to be slight, then, on the basis of Bjerrum's theory, the effect of the solvent co-ordination mechanism on the extraction of the complexes must be important, because this is the greatest factor which determines the distance apart of the charge centres. This co-ordination involves the question of steric hindrance where the size of the solvent molecule will obviously affect the factor *d* in the Bjerrum equation.

A study of the curves for gallium reveals a rather surprising fact (which is also obvious to lesser degree in Fig. 2), and this is the apparently greater efficiency of the asymmetric ethers for extracting the complexes compared with the symmetric compounds. In terms of extracting power, the three asymmetric ethers appear to be intermediate between ethyl and *iso*propyl ether, whereas steric considerations would tend to indicate an extraction potential certainly inferior to that of butyl ether. The symmetric ethers show a regular decrease in extracting power with increasing molecular weight, and the pattern is identical for indium and gallium.

This anomalous behaviour of the asymmetric ethers poses an interesting problem. A possible explanation may be that the greater dipole moments of these ethers play an important part in determining the extent to which they are able to enter the co-ordination sphere of the metal. It is considered that these higher dipole moments may lead to an increased electron density at the donor oxygen atom due to electrostatic forces within the molecule and hence increase the tendency of the solvent to co-ordinate with the appropriate metal.

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FATTY ACID PATTERN IN THE AORTA LIPIDS OF COCKERELS IN THE INITIAL STAGE OF CHOLESTEROL- OR STILBŒSTROL-INDUCED ATHEROSCLEROSIS

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IN the chicken, either the addition of cholesterol to the diet or the implantation of stilbœstrol pellets leads to a striking increase in blood lipids followed by the development of diffuse lipid infiltration of the inner parts of the aortic wall on which atheromata formation[1] is later superimposed. The mechanism of the atheromatous changes is poorly understood, although it is generally believed to be closely associated with cholesterol metabolism, which in turn is related to fatty acid metabolism[2]. In order to elucidate the relationship between fatty acid metabolism and the development of atheromatous changes a study was undertaken of the fatty acid composition of the cholesterol esters, triglycerides and phospho-

Table 1. The Fatty Acid Composition of the Lipids of an Intima-media Preparation of the Cockerel Aorta

Fatty acid		Cholesterol fatty acid Animal groups				Triglyceride fatty acid Animal groups				Phospholipid fatty acid Animal groups			
		A Control	*B* Cholesterol plus peanut oil	*C* Cholesterol, no oil	*D* Stilbœstrol, no oil	*A* Control	*B* Cholesterol plus peanut oil	*C* Cholesterol, no oil	*D* Stilbœstrol, no oil	*A* Control	*B* Cholesterol plus peanut oil	*C* Cholesterol, no oil	*D* Stilbœstrol, no oil
Saturated													
Pentadecanoic	15 : 0	1·8				0·3							
Palmitic	16 : 0	23·6	7·7	23·0	17·3	24·8	21·3	29·1	26·7	21·9	20·8	25·3	22·5
Heptadecanoic	17 : 0	3·1											
Stearic	18 : 0	13·4	2·1	5·2	8·1	19·9	15·2	16·1	10·1	21·3	15·6	19·6	20·4
Mono-unsaturated													
Palmitoleic	16 : 1	6·2	8·1	8·2	3·4	4·5	6·9	10·2	3·1	1·7	2·9	3·1	
Oleic	18 : 1	23·1	64·2	41·8	48·2	29·8	45·8	36·0	48·6	26·9	28·3	33·7	17·7
Di-unsaturated													
Linoleic	18 : 2	15·2	13·9	19·8	16·1	10·4	10·7	8·6	8·9	8·5	14·7	10·6	4·1
Poly-unsaturated													
Linolenic	18 : 3	1·8	1·3	0·7	2·5	4·1			1·4	0·2	1·1		
Arachidonic	20 : 4	1·6	1·1		4·4	1·7			1·2	11·8	11·5	7·7	
20–22 ?		6·4	1·5	1·2		3·5				6·5	5·1		16·1
24 ?													19·2

Group *A*, nine normal cockerels; Group *B*, three cockerels fed 1 per cent cholesterol plus 3 per cent peanut oil in the diet; Group *C*, two cockerels fed 1 per cent cholesterol without any oil; Group *D*, two cockerels implanted stilbœstrol pellets subcutaneously (no oil).
The tissues from the animals within the groups were pooled and the total fat extracted. The total lipids were separated into cholesterol esters, triglycerides and phospholipids on silicic acid.
Values are expressed as per cent of total fatty acid methyl ester.

lipids of the blood and aorta lipids in cockerels with experimental atherosclerosis.

The present report deals with part of the analyses carried out on the aortic lipids. The findings may be significant regarding the pathogenesis of atherosclerosis, because they indicate changes in the oleic acid metabolism.

The cockerels used were a cross-breed of White Leghorn and New Hampshire, 5 months old at death.

Three groups of three normal cockerels were fed ordinary chick starter mash mixed with grain (1 : 1). The results from these three groups were averaged and are presented as group *A* in Table 1. Three animals (group *B*) were given a supplement to the mash consisting of 1 per cent by weight of cholesterol and 3 per cent peanut oil during 10 weeks before killing. Two animals (group *C*) were given 1 per cent cholesterol *without* any extra oil. Two animals (group *D*) were treated with stilbœstrol. Pellets of diethylstilbœstrol, each containing 10 mgm., were implanted subcutaneously. Eight implantations were performed at intervals of 10 days during a 10-week period. The last implantation was performed 5 days before death.

The aorta (including the brachiocephalic trunks) was dissected free from any visible fat and loose connective tissue. Approximately the inner half of the aortic wall (about 200 mgm. wet weight) consisting of intima and part of the media was isolated for fatty acid analysis.

In two of the aortas from the cholesterol-fed animals (group *B*) non-elevated, white-yellow areas were found in the intima. In one of the aortas from the stilbœstrol-treated animals (group *D*) atheromatous changes were also found.

Cockerels fed cholesterol and 3 per cent peanut oil (group *B*) showed a 270 per cent increase in cholesterol and a 14 per cent increase in phospholipid in the inner one-half of the aortic wall. Cockerels fed cholesterol without oil (group *C*) showed a 50 per cent increase in aorta cholesterol. Animals treated with stilbœstrol (group *D*) showed a 190 per cent increase in cholesterol and a 24 per cent increase in phospholipids of the aorta as compared with normal controls.

The aorta preparations within the three animal groups were pooled, cut into small pieces, and then extracted with ethanol/ether (3 : 1). The combined extracts were evaporated under nitrogen, dried in vacuum and dissolved in light petroleum.

The total lipids were separated on silicic acid into three fractions: cholesterol esters, non-esterified fatty acids plus triglycerides, and phospholipids[3].

The fatty acids of the three fractions were isolated and the methyl esters prepared by treating with diazomethane in ether. The fatty acid composition was determined by gas-liquid chromatography according to James and Martin[4] using a Pye argon chromatograph with an ionization chamber as detector. Because of the complexity of the fatty acid pattern, it was necessary to chromatograph the mixed methyl esters on two different stationary phases, a polar polyester (*LHC-R*-296)[5] and silicone oil[6]. In addition chromatograms were performed on the mixed esters after complete hydrogenation in order to obtain an accurate chain-length analysis. The analytical procedures used in addition have been described earlier[6]. The results of the analysis are summarized in Table 1. The most striking differences between animal groups *A*, *B*, *C* and *D* were found in the cholesterol ester fatty acid composition. The cholesterol esters of the control group *A* contained only 23·1 per cent oleic acid compared with 64·2, 41·8 and 48·2 per cent in animal groups *B*, *C* and *D* respectively. The stearic acid concentration on the other hand decreased from 13·4 per cent in the control group *A* to 2·1, 5·2 and 8·1 per cent in groups *B*, *C* and *D*. The linoleic acid concentration of the cholesterol esters showed no significant changes in the different animal groups.

In the triglycerides the percentage of oleic acid showed similar changes as in the cholesterol esters but less pronounced. The percentage of stearic acid showed, however, only a tendency to decrease and the percentage of linoleic acid showed no differences.

The fatty acid composition of the phospholipids in the groups was remarkably constant with the exception of group *D* where an increase in fatty acids belonging to group C_{20-24}? was found. The exact nature of these fatty acids has still to be determined.

In connexion with the pronounced changes in the oleic acid and stearic acid percentage in the cholesterol and triglyceride fatty acids found here two papers are relevant. Klein and Martin[7] have found an increase in the liver cholesterol oleate pool of cholesterol-fed rats. James *et al.*[8] have described an increase in oleic acid and a decrease in stearic acid percentage in the fatty acids of the acetone-soluble lipids of plasma from patients with coronary artery disease.

Concerning the influence of diet in these experiments, it is apparent that without any additions to the diet the stilbœstrol-treated animals showed changes in the cholesterol ester and triglyceride fatty acids similar to the changes found in the two cholesterol-fed groups. All three treated groups showed hyperlipæmia and cholesterol accumulation in the aorta.

The implications of these observations can be more properly assessed when the fatty acid composition of the plasma lipids is also known.

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GROWTH AND MORPHOGENESIS OF *STRIGA* SEEDLINGS

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Effect of Light, Gibberellic Acid and Kinetin on Growth and Morphogenesis of *Striga* Seedlings

BOTH facultative and obligate parasites occur in the family Scrophulariaceae. An example of the former is *Rhinanthus minor* Linn.[1], which can grow without the host, producing roots and shoots as a normal plant and even setting seed. The growth of such plants, however, is generally slower, and the plants may be stunted compared with those which become attached to a suitable host. Among the obligate parasites belonging to this group, species of *Striga* are well known for attacking grain crops in tropical and sub-tropical countries. The seeds of these parasites require a germination stimulus which is produced by the roots of host plants. Saunders[2] demonstrated that leachings from sand in which the roots of maize had been growing could be used to germinate *S. asiatica* (= *S. lutea*) and to grow the seedlings for a short period without the host. In the present experiments a solution produced by growing a susceptible variety of *Sorghum vulgare* in small pots of sand for a number of days and eluting with water was used to germinate seeds of *S. asiatica*. In this solution seedlings produced a slender unbranched radicle (Figs. 1 and 2) up to 4 mm. long, but generally less, before the food reserves in the seeds were used up and the seedlings died. The radicle was usually strongly curved at first or grew in the form of a spiral, and root hairs were not generally produced although a few short hairs sometimes grew towards the radicle tip of older seedlings, and occasionally an abnormal, highly deformed seedling which sprouted root hairs was produced in such cultures.

The effects of light and the growth substance gibberellic acid and kinetin on this morphogenic pattern have been studied. In the growth-substance experiments young germinated seedlings (between 15 and 30 in each replicate) were transferred to small culture vessels in 1 ml. of the germination solution. To this was added 4 ml. of either water or the particular hormone solution under investigation. The cultures were maintained in the dark except for short periods when they were examined. Growth was recorded by means of camera-lucida drawings or photographically. In the light experiments seedlings were exposed to light of different qualities or kept in the dark. A No. 2 Photoflood lamp was used as a light source. The light was filtered through an infra-red filter and a water filter circulated with air-cooled water. This arrangement permitted the treatment of seedlings with fairly high-energy light without heating; light of restricted wave-length was obtained by the use of coloured glass filters. These were matched for equal energy transmission (using a simple thermopile and galvanometer) with a series of neutral filters made by reducing fogged (black) photographic film to the desired density. The accuracy of the thermopile and galvanometer permitted only approximate matching of the filters. The unfiltered light (about 2,500 ft.-candles at the level of the culture vessel) gave a galvanometer reading of 8 units, while the densest filter used gave a reading of 1·5 units. The neutral filters were used to adjust the other filters to give this reading on the thermopile galvanometer. Using this arrangement, only one light treatment could be studied at a time so that each result is compared with a separate dark control. The results of the light experiments are shown in Table 1.

The major effects of light were: (1) reduced extension growth of the radicle; (2) increased diameter; (3) the production of root hairs; (4) the occasional proliferation of cells into a branch-like swelling of the radicle. The number of root hairs shown in Table 1 refers only to those that were countable in a profile view of the seedlings, the actual numbers being considerably higher than this (some

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Table 1. Effect of Light of Different Qualities on Development of the *Striga* Radicle

Light quality	Transmission range of filter (mμ)	Max. transmission (mμ)	Extension growth light growth/dark growth	Diam. light/dark	Root hairs (av. per seedling over controls)
White	—	—	0·31	1·8	8·1
Blue	*c.* 350–650	490	0·45	1·6	7·4
Green	470–650	540	0·81	1·3	2·1
Red	600–*c.* 1,100	*c.* 650	0·68	1·3	2·5
Far-red	700–*c.* 1,100	*c.* 770	1·06	1·0	0

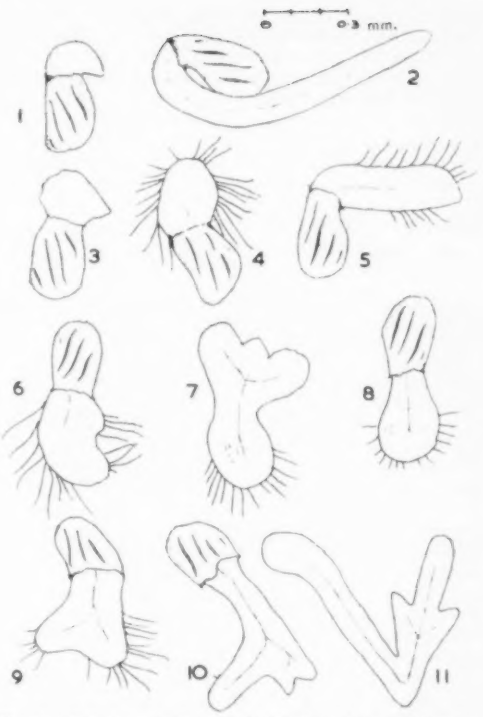
typical effects of light are illustrated in Figs. 3–5). The most effective wave-lengths in producing these morphogenic effects were in the blue region of the spectrum and to a lesser extent in the red. Far-red irradiation produced a slight, though not significant, increase in extension growth and was without formative effects. It was not tested whether far-red could reverse the effect of fixed exposures to light of the other wave-lengths. While the effects of red and far-red in many plant growth processes are reversible through the action of red and far-red absorbing forms of a special pigment system (for example, seed germination, flowering, internode extension, hypocotyl curvature, anthocyanin synthesis)[3–6], some plants are reported to be more sensitive to blue irradiation[7] in flowering and growth responses. According to Hendricks and Borthwick[6], photomorphogenic responses to blue light also arise from the absorptions of the photomorphogenic pigment. That the situation is probably more complex is indicated by the results of Stozwijk and Zeevaart[8] in which both blue and far-red were found to be more effective than red in promoting flowering of the long-day plant *Hyoscyamus niger*, while generally flowering of long-day plants appears to respond to red (and to be inhibited by far-red).

Gibberellin and kinetin are known to simulate certain effects of light; both promote leaf expansion and seed germination, while gibberellin simulates the effect of red light on the flowering of long-day and short-day plants (see review by Brian[9]). Brian postulates the action of red light in raising the level of a gibberellin-like hormone which may in some way affect the auxin status of plants. The effects of these substances on the development of *Striga* seedlings are shown in Table 2.

Kinetin had a striking effect on root hair production and radicle growth resembling the effects of light (Figs. 6–9). Root hair production and length of hairs were greatest at 1 p.p.m. and least at 100 p.p.m. At the 1 p.p.m. level kinetin induced branching in the radicle of some seedlings, with pro-vascular strands passing from each branch (Fig. 9). At the

Table 2. Effect of Gibberellic Acid (GA) and Kinetin on Development of *Striga* Seedlings

Treatment	Extension growth of radicle (mm.)	Diam. of radicle (mm.)	Root hairs (av. per seedling)	Branching of radicle (per cent seedlings)	Shoot expansion (per cent seedlings)
Control	1·08	0·10	1·4	0	0
GA					
0·05 p.p.m.	0·98	0·11	0·8	0	0
0·2 p.p.m.	0·63	0·14	2·3	0	0
1 p.p.m.	0·57	0·15	2·0	35	30
5 p.p.m.	0·50	0·13	0·8	50	35
25 p.p.m.	0·51	0·12	0·6	10	45
Kinetin					
1 p.p.m.	0·32	0·19	30	25	0
10 p.p.m.	0·29	0·22	18	0	65
100 p.p.m.	0·31	0·22	17	0	15



Figs. 1 and 2, stages in the growth of *Striga asiatica* seedlings in the dark without growth substance additions; Figs. 3–5, some effects of light on *Striga* seedlings; Figs. 6–9, effects of kinetin at various levels; Figs. 10 and 11, some effects of gibberellic acid on seedling development. (Camera-lucida drawings)

10 p.p.m. level, and to some extent at the 100 p.p.m. level, shoot development shown by expansion of the cotyledons and enlargement of the plumule were stimulated. (The effects of kinetin on root hair production and shoot development have been previously reported by Worsham *et al.*[10], who also report that kinetin at certain levels promotes germination of the parasite seeds. The resemblance of the effects of kinetin and light, however, has not to my knowledge been previously reported.)

The action of gibberellic acid resembled that of kinetin in inducing shoot development and branching of the radicle in some seedlings. With this substance, however, the radicle branches were more elongated and extension growth was not reduced to the same extent (Figs. 10 and 11); gibberellic acid had no significant effect on root hair production under these conditions, although it has been reported to promote root hair formation in excised pea roots[11]. Shoot development was pronounced with gibberellic acid at 5 and 25 p.p.m. and differed from kinetin in showing definite internode extension (Fig. 11). Clearly gibberellic acid does not simulate the effect of light in the development of *Striga* seedlings as does kinetin.

The morphogenic changes induced by light and these growth substances are of particular interest, since development in the dark beyond the stage of radicle extension in *Striga asiatica* normally only occurs if the parasite becomes associated with a suitable host plant. The production of shoots and the stimulation of root branching by kinetin and gibberellin indicate that the parasite probably

depends on a supply of growth factors of this type from the host for development, unlike the facultative parasites belonging to the same family (for example, *Rhinanthus*). Shoot development has never been observed to occur with light treatment alone. Various attempts have been made to prolong the growth of *S. asiatica* in culture by providing mineral nutrients and certain vitamins and organic compounds (for example, thiamin, nicotinic acid, pyridoxine, adenine), as well as kinetin, gibberellic acid and light; but chlorophyll development and growth beyond the stages indicated have never occurred.

Influence of the Host Rhizosphere on the Morphogenesis of *Striga* Seedlings

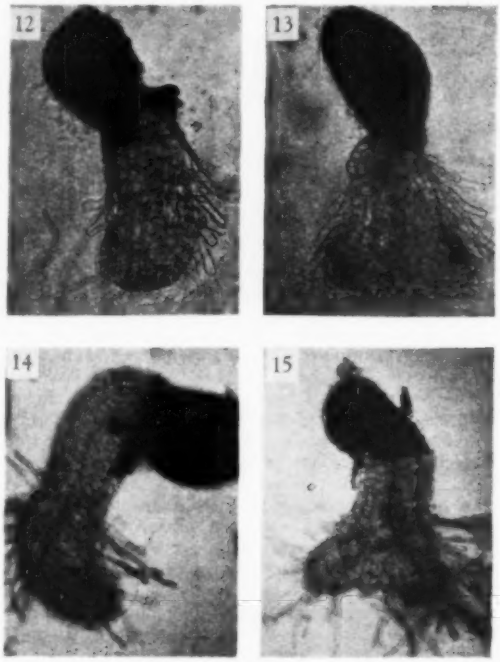
Using an agar culture technique, studies have been made on the development of the radicle of the root parasite *Striga asiatica* (= *S. lutea*) in the rhizosphere of a susceptible host plant. The method used was as follows: parasite seeds were treated with moisture on damp filter paper for about 10 days before use. The seeds do not normally germinate except in the presence of an exudate from the roots of a host plant (for example, sorghum, maize), and a period of moisture treatment is necessary for optimum germination. After moisture treatment the parasite seeds were mixed into an autoclaved 1 per cent agar solution at about 40–45° C., pipetted into 6-cm. Petri dishes and allowed to set. 10 c.c. of the agar seed suspension was pipetted into each dish (that is, several hundred seeds). Immediately after pipetting the agar, one host seedling (*Sorghum vulgare* var. Light Mori, from Nigeria) was rinsed briefly with sterile water and planted in each dish. The host seeds were surface sterilized with bromine water prior to germination, and the radicles at the time of planting were about 2 cm. long. The dishes were incubated in the dark at room temperature at a slight incline to induce the host radicles to grow across the dishes. Five or ten replicates were used, and the experiment was repeated on a number of occasions.

A germination factor, diffusing from the host radicle, caused the parasite seeds to germinate. Germination varied considerably between the replicates, but always increased with proximity to the host radicle. In addition to germination, growth-rate and morphology of the radicle varied strikingly with distance from the host radicle. The development of the parasite radicle in 4-mm. zones about the host root was measured by means of camera-lucida drawings. In the nearest zone the rate of extension growth of the radicle was very low, the radicle undergoing considerable lateral expansion and producing root hairs (Fig. 12). Occasionally branching of the radicle occurred (Fig. 13). In this zone the host root showed a definite positive chemotropic influence over the growth of the parasite radicle. In the second zone (4–8 mm. from the host root) the rate of extension growth of the parasite radicle was considerably increased, and lateral expansion and the production of root hairs were reduced. Similarly, in the third zone (8–12 mm. from the host root) the rate of extension growth was further increased and lateral expansion and root hair formation reduced. These results are listed in Table 3.

Table 3. Morphogenic Effect of the Host Rhizosphere on the Radicle of the Root Parasite *Striga asiatica*

Distance from host root	Root hairs* (average per seedling)	Extension growth (mm.)	Diameter (mm.)
0–4 mm.	12·2	0·45	0·16
4–8 mm.	2·7	0·95	0·13
8–12 mm.	1·5	1·25	0·10

* Only the root hairs visible in profile were counted; the actual numbers were considerably higher.



Figs. 12 and 13, typical morphogenic effects of the host rhizosphere; Figs. 14 and 15, effects of kinetin at a concentration of 1 p.p.m.

The results show that a factor having a strong morphogenic influence on the development of *Striga* seedlings is present in the host rhizosphere and is probably secreted by the host-plant root. It is of interest that similar effects on the development of *Striga* seedlings can be induced in cultures without the host by treatment with light (particularly blue light and to a lesser extent red), and with the light-simulating hormone kinetin [6-(2-furfuryl) amino-purine] (ref. 10 and previous communication). Figs. 14 and 15 show typical effects of kinetin at a level of 1 p.p.m. on *Striga asiatica* seedlings. Root hair production and lateral expansion of the radicle are stimulated and extension growth is strongly reduced, while some seedlings are induced to branch in a way very similar to that which occurs in the region of the host root. At higher levels (10 and 100 p.p.m.) shoot development was stimulated by kinetin. No shoot development was ever observed to result from exudates in the rhizosphere of the host, however, although shoot development commences shortly after contact is made with the host root.

Worsham *et al.*[10] have shown that certain 6-substituted amino-purines, including kinetin, stimulate the germination of *Striga asiatica* seeds at levels ranging from 5 to 25 p.p.m., and can replace the natural germination stimulant excreted by the host roots. The natural germination stimulant has not

to my knowledge, been identified, although chromatography of concentrates prepared from water in which the roots of sorghum had been growing revealed a highly active zone close to the solvent front[12]. This stimulant was thought to be similar to the *Orobanche* seed stimulant from linseed roots, which apparently also stimulates the germination of *Striga* seeds and has a similar R_F value[13]. Degradative work on the *Orobanche* stimulant, however, has shown it to have a small nitrogen value (0·5 per cent)[14] and therefore it does not appear to be a purine compound. A more recent investigation[15] on the *Striga* and *Orobanche* germination stimulants from maize roots shows that root extracts, and aqueous solutions in which the roots have been suspended, contain a number of stimulating substances for these seeds, including a water-soluble component and a number of ether-soluble components. Chromatographic analysis indicates that the factors from maize roots causing optimal germination of *Striga* and *Orobanche* seeds are different. Traces of solutions from linseed and sorghum roots acted synergistically with maize root preparations, suggesting that linseed, sorghum and maize may all produce a similar complex of stimulants, differing only in the proportions of the different constituents.

In view of the present results and the demonstration by Worsham *et al.*[10] that 6-substituted aminopurines can stimulate the germination of *Striga* seeds, it would seem possible that one of the components of the germination complex may be a kinetin-like compound, which both stimulates the germination of the parasite seeds and induces morphogenic changes in the seedlings. In this case the concentration required for germination would be considerably less than that required for the appearance of morphogenic effects.

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ACTION POTENTIAL WITH AN ARTIFICIAL *p*H-MUSCLE

By D. H. WALTERS, Prof. W. KUHN and HANS J. KUHN

Physical Chemistry Institute, University of Basle

AN artificial *p*H-muscle[1] consisting of a three-dimensional network, made from about equal quantities of polyvinyl alcohol and polyacrylic acid, has previously been shown to dilate and to contract reversibly when sodium hydroxide and hydrochloric acid was added alternately to its embedding medium, for example, 1×10^{-3} *N* sodium chloride solution. It was consequently demonstrated for the first time with the artificial cross-striated *p*H-muscle[2] that the chemically induced dilations and contractions are paralleled by chemical equilibrium changes if the length of the filaments are changed mechanically. These chemical equilibrium changes were also shown to occur in an analogous way with the homogeneous *p*H-muscle[3], the redox-[4] and the ion-precipitation-muscle[5]; and they are the basis for a transformation of chemical into mechanical energy by means of these systems and the establishment of corresponding general and quantitative relationships: the 'teino-chemical principle'[6].

In the course of comparing the behaviour of the artificial *p*H-muscle with the properties of the natural muscle, the potential between the inside of the artificial *p*H-muscle and its embedding medium was determined in a series of preliminary experiments, during: (1) an initial state of thermodynamic equilibrium, and then sequentially in (2) the various stages following a contraction or dilation stimulus. The latter potentials (2) will be seen to vary with time and may be referred to as action potentials, being characteristic for a system in which the dilations or contractions with the corresponding time-dependent interior changes are at the start, or in the subsequent course, of development.

High-polymer heat-vulcanized gel strips, consisting in the dry state of equal parts of polyvinyl alcohol and polyacrylic acid, were prepared and the polyacrylic acid content was partially (for example, 20 per cent) neutralized by placing the foils in an appropriate quantity of dilute aqueous sodium hydroxide. The partially neutralized gel strips were afterwards embedded in an aqueous 1×10^{-3} *N* sodium chloride solution, the volume of which was less than 100 times the swollen gel volume (for example, 4·0 cm. × 3·0 cm. × 1·0 cm.). After complete equilibrium with respect to both swelling and *p*H had been established between the swollen gel strip and its embedding medium, a small quartz capillary (filled with agar-agar and saturated potassium chloride, and which was connected to a saturated potassium chloride calomel electrode) was inserted into the swollen gel strip; the capillary end of a second and similar electrode assembly was introduced into the embedding medium. The electrical circuit was completed by connecting the metallic ends of the saturated potassium chloride–calomel electrodes to a calibrated Polymetron type 42*B* millivolt meter. A more detailed description of the experimental apparatus, conditions and procedure will be given elsewhere[7].

In the ensuing time–potential curves (Figs. 1–3*a*, *b*) the potential of the electrode inside the gel relative to the electrode in the embedding medium is represented by the ordinate, the time by the abscissa. On

inserting the internal electrode into the chemically stretched polyvinyl alcohol plus polyacrylic acid swollen gel strip (that is, a gel the polyacrylic acid content of which had been partially neutralized with aqueous sodium hydroxide), a potential is obtained which is represented by point *A* of curve *ABCD* in Fig. 1. This potential, which is constant in time (cf. part *A*–*B* of curve *ABCD* in Fig. 1) and negative with respect to the embedding medium, corresponds to a state of equilibrium between the gel strip and the embedding medium; it is identical with the Donnan potential[8] existing at the surface of the gel and the surrounding fluid.

With the addition of hydrochloric acid (for example, 3 c.c. of 0·1 *N*) to the embedding medium of the partially neutralized polyvinyl alcohol plus polyacrylic acid swollen gel strip (point *B* of curve *ABCD* in Fig. 1) a contraction stimulus is applied to the gel. The potential rises rapidly from a negative value (point *B* of curve *ABCD* in Fig. 1) to a highly positive value (point *C* of curve *ABCD* in Fig. 1) and then gradually decreases with increasing time to a final value (point *D* of curve *ABCD* in Fig. 1). The potential drops to zero (example, point *D* in Fig. 1) if the amount of hydrochloric acid added to the embedding medium is sufficient to convert all of the sodium polyacrylate in the gel to polyacrylic acid.

The potentials represented by points *A*, *B* and *D* in Fig. 1 are equilibrium potentials; they are completely accounted for by the respective ion concentrations in the gel and the embedding medium. The potentials between points *B* and *D*, in particular the potential at point *C* of Fig. 1, correspond to a non-equilibrium state of the system. Point *C* of curve *ABCD* in Fig. 1 (the spike of the overshoot of the time–potential curve) represents the potential of the chemically stimulated partially neutralized polyvinyl alcohol plus polyacrylic acid swollen *p*H-muscle at the point of its first major perceptible contraction (ref. 7*a*). Qualitatively, the positive potential value of the gel at point *C* (Fig. 1) is due to the hydrogen ions moving from the acidified embedding medium into the interior of the gel, the product of concentration and mobility of the hydrogen ions being the highest of all ions that are present at the interface of

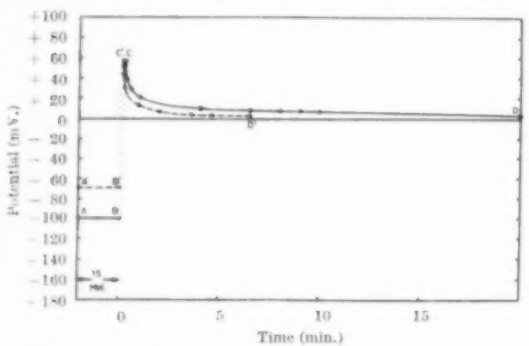

Fig. 1. Time–potential curves produced at 20° C. by hydrochloric acid on: (1) Partially neutralized swollen polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution (curve *ABCD*); addition of hydrochloric acid to the embedding medium at time zero, corresponding to point *B*; first major perceptible contraction begins at point *C* and accompanies the time–potential curve *C*–*D*

(2) Acidified swollen non-contractile polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution (broken curve *A'B'C'D'*); addition of hydrochloric acid to embedding medium at time zero, corresponding to point *B'*; no perceptible contraction of this (acidic) gel strip

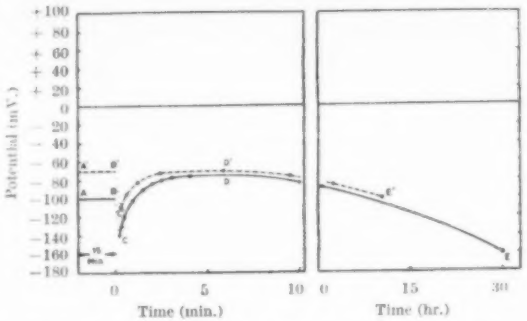

Fig. 2. Time–potential curves produced at 20° C. by sodium hydroxide solution on:

(1) Partially neutralized swollen polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution (curve *ABCDE*); addition of sodium hydroxide solution to the embedding medium at time zero, corresponding to point *B*; first major perceptible dilation of gel strip begins at point *C* and accompanies the time–potential curve *CDE*

(2) Acidic swollen non-contractile polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution (broken curve *A'B'C'D'E'*); addition of sodium hydroxide solution at point *B'*; first major perceptible dilation (relaxation) begins at point *C'* and ends at point *E'*

Serrated edges of time–potential curves represent time-lapse

the gel and therefore dominating the potential. In the subsequent time period (between point *C* and point *D* of Fig. 1) the details of the explanation become more complicated; the concentration gradients due to ionic diffusion both inside and outside the gel, the reaction of the sodium polyacrylate with the hydrochloric acid, and the general or local contraction of the gel, will develop and may lead to local potential gradients of different sign and magnitude. The observation of a strong peak of positive potential after the administration of the chemical contraction stimulus is the main feature of curve *ABCD* of Fig. 1.

The effect of hydrochloric acid on an acidic swollen non-contractile polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution is represented by curve *A'B'C'D'* and text in Fig. 1; a more detailed discussion will appear elsewhere[7].

When a partially neutralized or acidic polyvinyl alcohol plus polyacrylic acid gel strip, again prepared and embedded in 1×10^{-3} *N* sodium chloride solution as in the previous experiments, is given a dilation stimulus by the addition of sodium hydroxide solution (for example, 3 c.c. of 0·1 *N*) to the embedding medium, an immediate potential peak of the opposite sign is observed (that is, the internal gel electrode becomes more negative relative to the outer electrode in the embedding medium (Fig. 2)).

The peak of the negative potential (points *C'* and *C* of Fig. 2, that is, the point where the alkali-stimulated gel begins its first major perceptible dilation) is followed by a drop of the absolute value of the negative potential and after a long period by a moderate increase of the negative potential value towards a final equilibrium value which again can be explained by the state of gel swelling, and of the ion concentration both inside and outside the gel present in the final equilibrium state: curves *ABCDE* and *A'B'C'D'E'* of Fig. 2.

It is interesting to note that a contraction stimulus (produced by the addition of acid to the embedding medium) followed a short time later by a dilation stimulus (a relaxation stimulus produced by the

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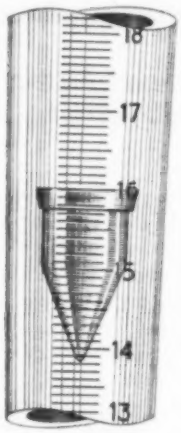

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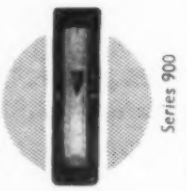
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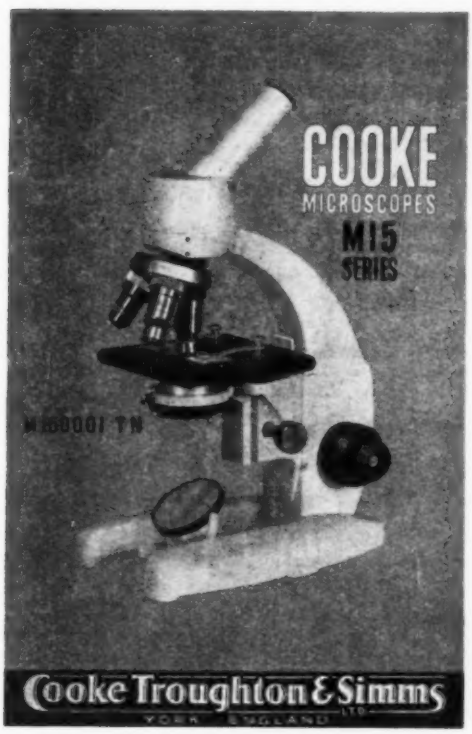

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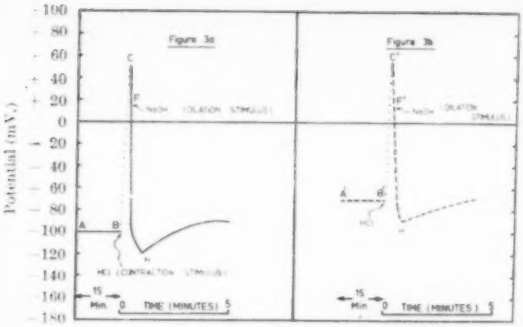

Fig. 3a. Time–potential curve for the effect of hydrochloric acid (contraction stimulus) followed a short time later by the addition of sodium hydroxide solution (dilation stimulus) on a partially neutralized polyvinyl alcohol plus polyacrylic acid swollen gel strip embedded in 1×10^{-3} *N* sodium chloride solution; this curve is a superimposition of curve *ABCD* of Fig. 1 on curve *ABCD* of Fig. 2 with a small time shift of the latter curve. Hydrochloric acid added at point *B*; first major perceptible contraction would be observed, under the present experimental conditions, at point *C*. Sodium hydroxide solution added at point *F*; dilation would begin shortly after point *F* and continue until the final equilibrium point. The significance and means of varying the slope and duration of the line *CFH*, and the recovery period beyond point *H*, will be presented elsewhere (ref. 7)

Fig. 3b. Time–potential curve for the effect of hydrochloric acid followed a short time later by the addition of sodium hydroxide solution (dilation stimulus) on an acidic swollen non-contractile polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution; this curve is a superposition of curve *A'BC'D'* of Fig. 1 on curve *A'BC'D'* of Fig. 2 with a small time shift of the latter curve. No perceptible contraction of gel strip on addition of hydrochloric acid. Remainder of legend as for Fig. 3*a*

addition of alkali to the embedding medium) of the swollen partially neutralized gel strip will produce a time–potential curve (for example, Fig. 3*a*) which has many of the characteristics of the time–potential curve (that is, of the action–potential curve) of various biological tissues[8]; in fact, the same curve of Fig. 3*a* is produced by a superimposition of curve *ABCD* in Fig. 1 on curve *ABCD* of Fig. 2 with a small time-shift of the latter curve.

Fig. 3*b* shows the effect of the addition of hydrochloric acid followed later by the addition of sodium hydroxide solution on a swollen non-contractile acidic polyvinyl alcohol plus polyacrylic acid gel strip embedded in 1×10^{-3} *N* sodium chloride solution; this will be discussed at greater length elsewhere[7].

A comparison of the resting, action and recovery potentials observed with various biological tissues[8] and the potentials observed with the high-polymer *p*H-muscle reveals some obvious formal analogies. Further ways of producing by appropriate means in other artificial high-polymer systems (for example, cross-striated *p*H-muscle, redox- and ion-precipitation-muscle) potentials dependent on time and similar to the different action–potential curves of various biological tissues will be given elsewhere[7]. Subsequent papers will also include the more complicated time–potential curves for high-polymer systems when acids and/or bases and other chemical substances are introduced either separately or in combination into the interior of the neutralized or acidic gel and/or the embedding medium at the same time or after a specific time lag, plus a discussion of the chemical and physical properties which influence the specific time–potential curve[7].

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[3] Kuhn, W., *et al.*, in the press (1960–61); addendum, *Experiments in Progress*: (*a*) birefringence and tension studies to determine their relationship to the time–potential curve and to the *initial* points of contraction and dilation; (*b*) oscilloscopic (with attached camera) msec. study of slope and duration of lines *BC* and *B'C'* of Figs. 1–3*a*, *b*; (*c*) continuation of present studies on gel blocks cross-linked by other techniques (for example, chemical and irradiation).

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PHOTOGRAPHIC CUMULATION OF RECURRENT RESPONSE POTENTIALS

By Prof. LORRIN A. RIGGS and C. R. CAVONIUS
Hunter Laboratory of Psychology, Brown University, Providence, Rhode Island
AND
Dr. E. PARKER JOHNSON
Colby College, Waterville, Maine

INTERMITTENT illumination of the human eye elicits a corresponding succession of response potential waves in the electroretinogram. Lord Adrian[1] has shown that these waves have negative and positive components the form of which is related to the frequency and intensity of the stimulating flashes. Much interest now centres on isolating the small responses characteristic of the photopic or colour-specific systems of the eye[2,3]. Unfortunately, a relatively large background of electrical 'noise' is usually present in an actively responsive system such as the eye. Often it is true that the signals generated in response to the light are smaller than the 'noise' that is unrelated to the stimulus.

One time-worn procedure for separating evoked potentials from irrelevant ones has been the comparison of several samples of record made under conditions such that they ought, apart from contamination, to appear identical. This is helpful; but the unaided eye is incapable of making these comparisons in a completely unbiased manner, and most workers agree that the required integration and abstraction would be better carried out using some more objective procedure. The use of electronic computers offers an exciting prospect of unheard-of sensitivity in the recording of biological potentials[4]. The apparatus, however, is complex and costly. It is usually not feasible to occupy such elaborate equipment throughout the routine, day-after-day exploration of individual electrophysiological phenomena.

The present article describes a simpler procedure, one which stores and cumulates its information on

photographic film during successive exposures. We have applied the method specifically to the registration of the electroretinogram and have been able to identify components with amplitudes of less than one microvolt. The principle appears easily adaptable to any of a broad range of problems in which the response is stimulus-locked.

Our apparatus for cumulating electrophysiological responses is illustrated in Fig. 1. Light from a small tungsten filament is collected by a spherical mirror, directed through a rectangular aperture, and focused on the mirror of a bifilar oscillograph galvanometer having a natural frequency of 4,000 cycles/sec. A collimating lens in front of the galvanometer provides an image of the aperture in the form of a uniformly illuminated, rectangular patch of light. The rays forming this patch are reflected downward by a right-angle prism on to a horizontal diaphragm pierced by two rectangular windows. Any deflexion of the galvanometer mirror causes a proportional amount of light to traverse window N or window P, depending on the direction of movement of the mirror. In the null position the light falls between the two windows, illuminating neither.

When the eye is stimulated by a flash of light the negative and positive phases of the ensuing retinal potential, as amplified and fed into the galvanometer, are represented in the amounts of light traversing windows N and P. To record this, a cylindrical drum is wrapped with photographic film and rotated on a shaft directly below the windows of the diaphragm. A cylindrical lens focuses the light coming through the two windows on to the drum as two narrow lines of light. These, as the drum rotates, make parallel ribbons of exposure on the film, representing windows N and P.

To use the device for the cumulative recording of evoked potentials it is only necessary to synchronize the stimulus with the rotation of the drum. We have mounted a flicker-vane with four open sectors on the same shaft as the recording drum. Light passing through the open sectors provides the eye with a succession of flashes each of which evokes a response actuating the oscillograph galvanometer. A shutter is then opened, admitting the light to the rotating film for a fixed period of time—long enough to include the responses to several hundred flashes. The developed film appears as in Fig. 2. Variations

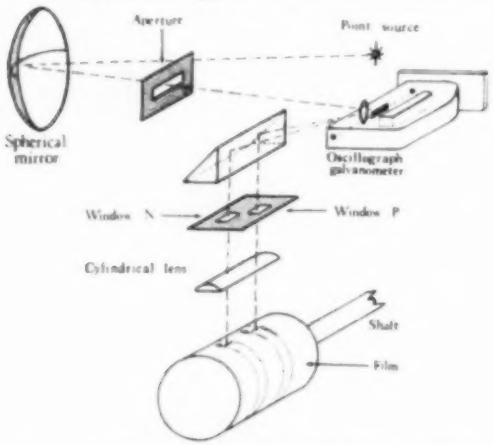

Fig. 1. The optics of the photographic cumulator—a schematic representation

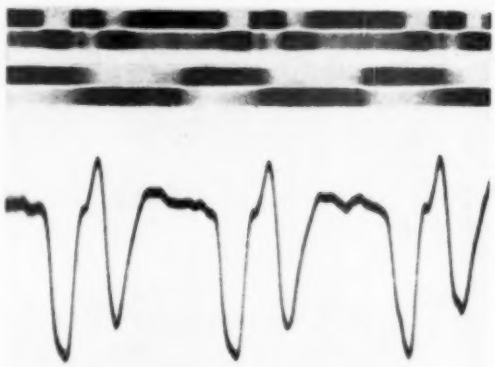

Fig. 2. Film records of cumulated electroretinal responses at two different flicker-rates, 30 per sec. (bottom pair) and 10 per sec. (top pair). The latter pair has been scanned with a recording densitometer to yield the 'average response' pattern shown beneath. Three response cycles are shown, each one being a cumulation of 75 individual responses

in density indicate the existence of synchronous responses; randomly occurring 'noise' only adds a nearly uniform darkening of the two tracks. In our system, with four flashes per revolution, we see four cycles of density variation on each pair of tracks.

To 'read' our film records we use a double-beam densitometer and record the difference in density, between the two tracks, as a function of phase position. An oscillographic record of the output of the densitometer appears below the film in Fig. 2. This record shows the main features of the response without serious contamination by background 'noise'. Calibration of the system shows that it is reasonably linear despite the fact that film density is logarithmically related to exposure. This is because the method is one in which the final result is given by relatively small differences in densities that are nearly equal between the two tracks. For more exact determinations of the absolute potential-levels it would be necessary to develop the negative under conditions resulting in a photographic gamma of unity, printing a film positive under the same conditions, and finally scanning this positive with photocells having a linear response to light intensity.

The optical method of cumulation has proved its ability to reduce irrelevant potential 'noise' and hence to reveal stimulus-locked responses of very low amplitudes. We are now able to record electroretinographic responses to light that is flickering at a rate considerably higher than the critical frequency of fusion as seen by the observer. The method has the disadvantage that conditions of exposing, developing and scanning the photographic film must be given careful consideration and selected for appropriateness. It has the advantages of simplicity, reliability and low cost, coupled with the fact that there is continuous rather than discrete time-sampling of the response potentials.

This research was supported by research grant No. *B* 1453 from the Institute of Neurological Diseases and Blindness, National Institutes of Health, U.S. Public Health Service.

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LETTERS TO THE EDITORS

PHYSICS

High Strength Glass

It was reported recently[1] that the major stress-raising defects on the surface of freshly drawn fibres of glass are visible, local defects which arise through the interaction of the hot glass with dust particles or other contamination. In that work very approximate values of the tensile stress which small areas of the surface, free from visible defects, would withstand without fracture were obtained. This communication is to report some results of further experiments to measure the actual breaking strengths of 'defect-free' samples of several commercial glasses.

Two methods have been used to prepare fibres of diameter 350–700μ which are free from visible defects, and these have been tested in 3-point bending using a gauge-length of 7 mm. and knife edges covered with polytetrafluoroethylene. For the first series of experiments lengths of fibre were produced by hand drawing from sections of $\frac{1}{4}$-in. diameter commercial rod which had been etched in 20 per cent hydrofluoric acid immediately before drawing. The centre of the rod was heated in an oxygen–coal-gas flame until quite fluid, removed and allowed to cool slightly before drawing. In a series of draws occasional defects are to be found, so that this simple procedure is not ideal. However, it has been found possible to eliminate from the results the more obvious cases of samples weakened by the presence of a defect, as described here. For the second series of experiments no precautions were taken to prevent the formation of defects during the heating of the rods before drawing. Instead, they were removed from the surface of the fibres after drawing by etching in hydrofluoric acid.

A sufficiently prolonged attack leaves smooth saucer-shaped pits in the fibre surface at the sites of the original defects. For samples of $\times 8$ glass, etching for 5 min. in a 10 per cent solution of hydrofluoric acid was sufficient to achieve this, and reduced the diameter by approximately 60μ. Samples etched for 10 min. in the same solution did not show significantly different strengths. Similar treatment of 'Pyrex' specimens removed much less material; the strengths

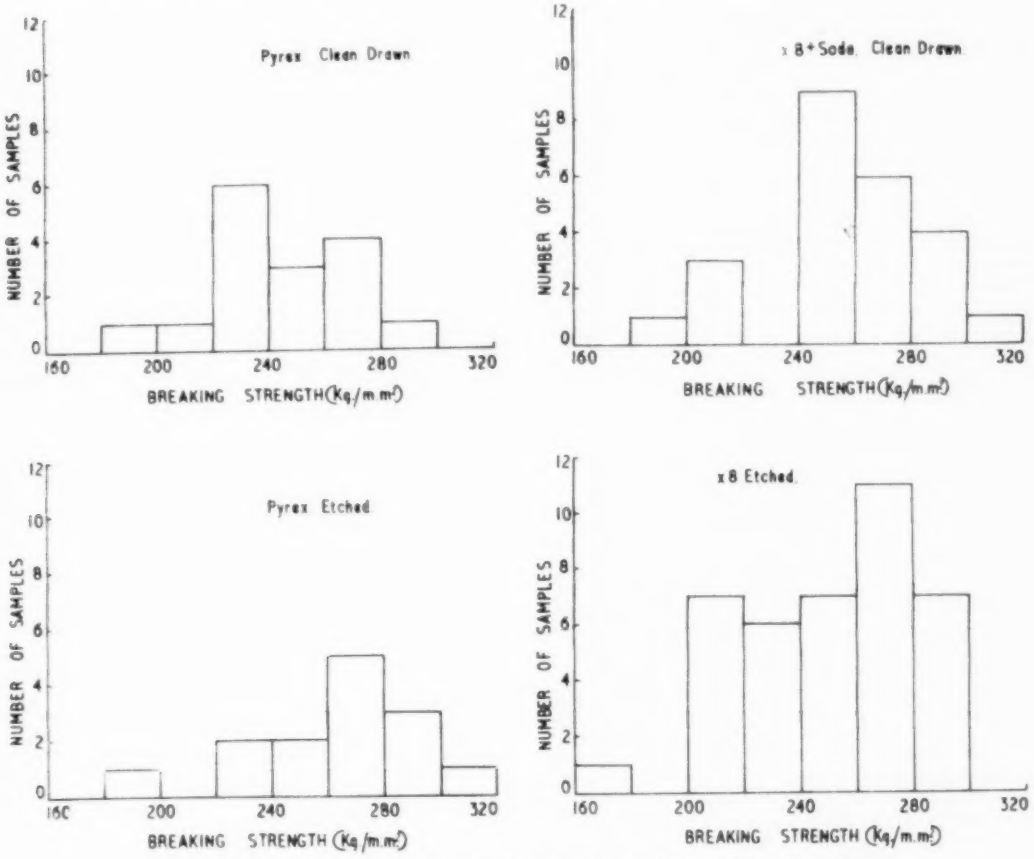

Fig. 1. Histograms illustrating the results obtained with 'Pyrex' and soda-lime-silica glasses

Table 1. SUMMARY OF RESULTS. IN THE SECOND COLUMN C INDICATES 'CLEAN DRAWN' SAMPLES AND E INDICATES ETCHED SAMPLES

Glass	Type of sample	No. of samples	Mean strength (kgm./mm.²)	Coefficient of variation
E-glass	C	24	343	7
Soda-Lime ×8	C	11	251	12
Soda-Lime ×8	E	39	250	12
Soda-Lime Unknown	C	13	257	10
'Pyrex'	C	16	242	11
'Pyrex'	E	14	265	8
Silica ('Vitreosil')	C	23	350	11
Silica ('Vitreosil')	E	11	361	

were lower and the pits were more angular. Immersion for 5 min. in a 40 per cent solution did, however, yield appreciable attack and smooth shallow pits. It is the results for these samples which are quoted in Table 1.

The diameters of the broken ends of the specimens were measured with a micrometer eyepiece attached to the microscope. With the strong specimens considerable shattering occurred so that it was not possible to measure the diameter at the position of fracture, nor indeed to locate the origin of fracture. This feature did, however, enable us to eliminate from the results the comparatively few samples from the first series which failed at a 'defect', for when shattering did not occur it was possible to examine carefully both fracture surfaces and invariably to detect a visible defect at the edge of the mirror zone.

The breaking strength was assumed to be the maximum tensile stress at the surface and was computed using the simple formula for the stresses in a bent beam. Quite large deflexions do occur in these tests, but from the expressions given by Freeman[2] the errors involved in using the simple equations for the stresses do not exceed 2 per cent for most of the fibres and are less than 10 per cent for the finest.

The histograms of Fig. 1 illustrate the results obtained with 'Pyrex' glass and soda-lime-silica glasses, while all the results obtained in this preliminary series of experiments are summarized in Table 1. The results for etched *E*-glass fibres are not included because for this glass the reaction was complicated by the growth of layers of reaction product at the glass surface, and etching in hydrofluoric acid has not proved satisfactory for removing defects to leave a smooth surface.

Tests were made with the first type of sample at times varying from 4 min. to several days after production. No significant differences were observed in the strengths. Some of the etched samples were tested while still wet with distilled water from the rinsing bath; these also showed no significant difference in strength.

We conclude that the high and relatively consistent values of the breaking strength obtained in these experiments support quantitatively the suggestion made earlier that the visible defects are a major source of surface weakness[1]. The strengths are comparable with those obtained by Thomas[3] and Otto[4] for very fine fibres of *E*-glass, although still lower than that expected from theoretical estimates which assume a homogeneous structure for a glass.

The residual scatter in our results is larger than is to be expected from experimental errors, which is estimated to be less than ± 10 per cent for any individual determination. Since the magnitudes and the variabilities are similar for both the 'clean draw' and the etched samples of the several glasses, it seems unlikely that the scatter is due to undetected defects of known type in the surface. It has been established that the scatter in breaking strength for ×8 samples rises significantly when deliberate variations are made in the interval between removal of the rod from the flame and drawing the fibre. We think, however, that detailed discussion of these results and of the possible causes of the residual variability in strength should await the results from further experiments which are now in progress. These will enable samples to be produced under more carefully controlled conditions, to be annealed without the formation of fresh surface defects and to be tested so as to avoid any perturbing effects from the knife edges.

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Tortuosity in Porous Media

THE tortuosity, T, of a porous medium such as sandstone is a quantity that has been interpreted in various and sometimes conflicting ways, particularly its relation to porosity, φ, and formation factor, F (refs. 1–4). Tortuosity originally was understood to mean the square of the quotient average length of a flow-line divided by the net distance traversed; and formation factor was the electrical resistivity of a porous medium divided by the resistivity of the saturating liquid.

Wyllie and de Witte[5] have presented one of the several possible ways of showing that:

$$T = \varphi F \qquad (1)$$

is the only logical relation for models where the average volume of the pores is equal to their average length multiplied by their average cross-section. Equation (1) has been considered obvious by numerous investigators. However, it is not automatically correct for real systems, for which the value of T depends on the way the averages are taken. For example, in a randomly oriented set of straight uniform pores, the combination of their resistances in parallel shows that equation (1) holds with the harmonic mean of T and the arithmetical mean of the areas, while for a single pore of variable cross-section the reverse is approximately true.

Some rough calculations will serve to illustrate the chief characteristics. The geometry of 'flow-lines' accounts for both 'sinuosity' and 'convergence' of 'pores'[6]. Consider a conical segment expanding from radius a_1 to radius a_2, with straight flow-lines uniformly distributed. Let $r(x)$ be the distance of a flow-line from the axis; $r(0) = r_1$ and $r(L) = r_2$. Let θ be the angle between the flow-line and the axis; $\tan\theta = (r_2 - r_1)/L$; $(a_2 - a_1)/L = \tan\Theta$, where Θ is the angle of the wall. For uniform distribution, $dr_2 = (a_2/a_1)dr_1$. Then:

$$\frac{1}{T} = \int_{\theta=0}^{\Theta} \cos^3\theta \, dr \Big/ \int_{\theta=0}^{\Theta} r\,dr = \frac{(\log \sec^2\Theta)}{\tan^2\Theta}$$

Now let δC be the total conductance of a sheath-shaped tube of flux between two conical surfaces: θ = const. and $\theta + \delta\theta$ = const.

$$\frac{1}{\delta C} = \rho \int_0^L \frac{\mathrm{d}x/\cos\theta}{2\pi r . \cos\theta(\partial r/\partial\theta)\delta\theta}$$

where ρ is the fluid resistivity. The integration is performed by using the relation: $r = (x + a_1/\tan\theta)\tan\theta$. The resulting expression is used to obtain the resistance of the whole segment:

$$R = 1/\int_{\theta=0}^{\Theta} \delta C = (\rho L \tan^2\Theta)/(\pi a_1 a_2 \log \sec^2\Theta)$$

Whence, for some arbitrary total area A:

$$T = (\pi a_1 a_2/A)F < \varphi F \qquad (2)$$

A measure of T independent of φ and F is possible, in principle, by such devices as transference lag[5] or transient diffusion[7,8]. If tortuosity is due mainly to pore 'sinuosity', and the arithmetical mean were measured, it might be that $T > \varphi F$, as the harmonic mean, appropriate for T in equation (1) for this case, is usually smaller. According to equation (2), the opposite would be expected when there are large variations of size in the pores.

Some authors have preferred to divest tortuosity of its geometrical significance and regard it simply as an impedance factor[9]. From this point of view, the tortuosity in the conical segment may be equated to φF, provided the corresponding approximation is made that the total resistance is the sum of the resistance of successive elementary segments in series. This familiar device amounts to assuming that flow-lines are geometrically parallel within each elementary segment. The result is:

$$T = (a_1^2 - a_1 a_2 + a_2^2)/3a_1 a_2 \qquad (3)$$

An analogous calculation for tortuosity in fluid-flow defines hydraulic resistance in terms of viscosity, η, as:

$$W = \frac{8\pi}{\eta} \int_0^L \mathrm{d}x/a^4$$

and a 'hydraulic formation factor', F_H, by:

$$W = \frac{F_H}{A} \int_0^L \frac{\mathrm{d}x}{\omega(x)}$$

where $\omega(x)$ is the average Poiseuille's-law mobility for the elementary segment at position x, given by:

$$\omega(x) = \int_0^a \omega(x,r)\,\frac{\mathrm{d}v}{\mathrm{d}r}\,\mathrm{d}r \Big/ \int_0^a \frac{\mathrm{d}v}{\mathrm{d}r}\,\mathrm{d}r$$

with

$$\omega(x,r) = (a^2 - r^2)/4\eta$$

$$v = \omega \mathrm{d}P/\mathrm{d}x$$

Integrating and combining:

$$F_H/A = (a_1^2 + a_1 a_2 + a_2^2)/3\pi a_1^2 a_2^2$$

which leads to:

$$\varphi F_H = [(a_1^2 + a_1 a_2 + a_2^2)/3a_1 a_2]^2 \qquad (4)$$

Equation (4) gives the square of the corresponding expression for electrical tortuosity in equation (3), but does not represent the geometrical tortuosity of the flow-lines. This provides a qualitative explanation for the fact that $(\varphi F)^2$ is the correlation function that has been derived from permeability experiments[1,10], while measured tortuosities have been close to φF in electrical migration and diffusion[5,9].

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Proton Relaxation in Crude Oils

IT was shown by Gutowsky, Ray, Rutledge and Unterberger[1] that crude oils exhibit electron resonance and by Poindexter[2] that the Overhauser effect is found in crude oils. The existence of the Overhauser effect depends on at least a part of the relaxation of the protons being due to the free electrons. Because the electron resonance and Overhauser effect results vary from sample to sample, it seemed of interest to make proton relaxation measurements on a number of samples of crude oil. The proton relaxation in crude oils is also of interest because of the introduction of proton precession instruments for underground measurements in oil wells[3].

Thermal relaxation, viscosity and density data were obtained for twelve Texas and two California crude oils. Temperatures were varied from 3° C. to 100° C., and field strengths varied from about 0·02 gauss to 7,000 gauss. Detailed relaxation curves were obtained by use of a low-field free-precession apparatus. Care was taken that the oils did not change composition by evaporation between measurement of viscosity and sealing of samples in 'Pyrex' bottles for relaxation measurements. Signal decay, or transverse relaxation, curves also were obtained in the Earth's field.

Fig. 1 shows that relaxation time is closely correlated with viscosity, despite a great range of composition of crude oils even in the limited selection of fourteen samples, and despite a probable variability of free-electron content. Apparently, only a fairly small fraction of the proton relaxation is due to the free electrons in most oils. There was no striking correlation between relaxation time and density. The relaxation times that are plotted in Fig. 1 are the reciprocals of the initial slopes of the relaxation curves, that is, the reciprocals of the average relaxation-rates. These results are for relaxation at 15 gauss. It was noted that the variation of T_1 with temperature for any one oil has about the same slope on a log–log plot as the general trend shown in Fig. 1.

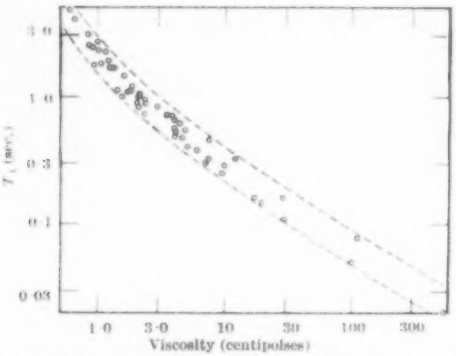

Fig. 1. Thermal relaxation times versus viscosity for 14 crude oils at various temperatures

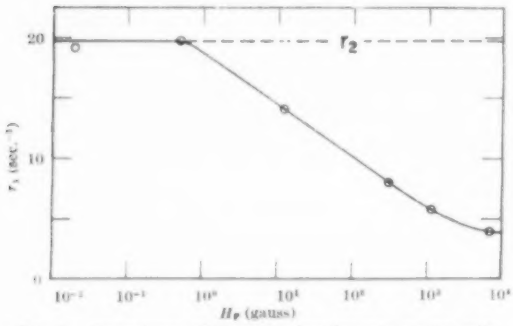

Fig. 2. Dependence of thermal relaxation-rate on magnetic field-strength for a crude oil sample

It was further noticed that there is no discontinuity at the 'pour point' for the oils exhibiting this phenomenon, although the macroscopic viscosity changes drastically as the temperature is lowered through this point.

Most of the crude oils showed a slight dependence on field for relaxation times, but only one sample exhibited strong dependence on field. The relaxation-rate (reciprocal of relaxation time) is shown as a function of field-strength in Fig. 2. At very low field-strengths, the thermal relaxation-rate is equal to the transverse relaxation-rate, which is indicated in Fig. 2 by the dashed line labelled r_2. Precession frequencies are presumably comparable to correlation frequencies in the range of field-strengths for

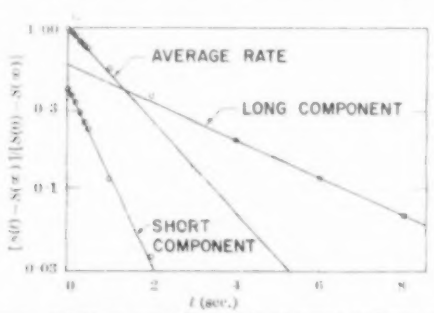

Fig. 3. Relaxation curve for a crude oil sample (different from sample represented in Fig. 2). S is the signal amplitude observed after allowing relaxation for a time t at the field for which relaxation data are desired

which the relaxation-rate drops off with increasing field. If some of the relaxation is due to free electrons in the sample, it may well be that frequencies of electron precession are involved in the observed dependence on field.

For all the oil samples the relaxation curves were noticeably non-exponential, and most of the curves can be represented within the accuracy of the data by the sum of two exponentials. In one of the samples there appeared to be an additional component of small amplitude and short relaxation time. The ratios of the pairs of relaxation times required to represent the relaxation curves varied from just over one to about five. The curves were carried out for relaxation by four powers of e in most cases. In many cases it was not possible to distinguish a curve composed of two distinct exponentials from a curve containing a distribution of relaxation-rates. Fig. 3 shows the relaxation curve for an oil for which the two relaxation-rates differ by a factor of nearly five. The curve labelled 'short component' shows the difference between the experimental points and the straight line labelled 'long component'. For this sample there appears to be two well-separated relaxation-rates.

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BIOPHYSICS

Direct-Current Conductivity of Textiles, Proteins and Other Polymers

There has emerged from a recent study of the electrical conductivity of dry cytochrome *c* (ref. 1) an understanding of two properties of the conductivity of a variety of natural and synthetic polymers:

(1) The two commonly observed conductivity–sorption relations (1) and (2) (ref. 2) are expressions of one mechanism; namely, conduction by ions in a medium of very low dielectric constant:

$$\log \sigma = A.M + \text{const. (small } M\text{)} \qquad (1)$$

$$\log \sigma = B.\log M + \text{const. (intermediate } M\text{)} \qquad (2)$$

where σ is conductivity; M, moisture content; and A and B, constants characteristic of the material. It is also observed that A is in the range 0·1–1 for a variety of materials, and B, 6–16.

(2) That the activation energies of conduction for dry amorphous substances should commonly exceed 25 kcal. (1·1 eV.) (ref. 1) is also understandable in terms of the same mechanism.

The theoretical approach adopted in ref. 1 was first used by King and Medley[3] in studying the conductivity–sorption relations of keratin and nylon, water and formic acid. They had previously shown that in moist keratin the current carriers were ions[4]. Treating the system by Bjerrum's theory of weak electrolytes, the polymer being considered the solvent, they were able, using their measurements on the dielectric constant of the system, to calculate curves of the fraction of unpaired ions versus the sorbent concentration, which reasonably reproduced important features of the conductivity-sorption

curves. The semiquantitative agreement confirmed their expectation that variation of the number of charge carriers had a greater effect on the conductivity than the variation of carrier mobility, but that the latter was not negligible. King and Medley's approach merits wider consideration.

To demonstrate point 1, one displays the dependence of the fraction of free ions (α) on the dielectric constant (D), using the expression for the pairing equilibrium, which Fuoss[5] gives as:

$$(1 - \alpha)/c\alpha^2 = (4\pi N_0 a^3/3000) \exp[|Z_1 Z_2| e^2/aDkT] \quad (3)$$

(c is total concentration in moles/litre; N_0, Avogadros' number; a, the distance between the centres of the ions in the pair; the other symbols have their usual meaning). Under the conditions of low dielectric constant that exist in polymers, the fraction of free ions is so small that the α in $1 - \alpha$ may be neglected, permitting one to write:

$$\ln \alpha = -cK_0/2 - Q/2aDT \quad (4)$$

where K_0 and Q represent the known constants. If one substitutes for D the approximation $D = D_0 + \beta M$, and writes α_0 as the value of α for $M = 0$, one obtains:

$$\ln(\alpha/\alpha_0) = (Q/2aD_0T).[\beta M/(D_0 + \beta M)] \quad (5)$$

For M small enough $\ln \alpha$ is linear in M; this is the basis of equation (1). The constant A is approximately $Q\beta/2aD_0^2T$. Calculated values of A agree with the observed closer than by an order of magnitude.

It is a property of rectangular hyperbolas such as (5) that they give a sigmoid curve when plotted versus $\ln M$ instead of M. In the region of the inflexion point an expression of the form of equation (2) holds. The original approximation used for D is not valid for the larger values of M, but a new linear approximation can be used which is valid in the appropriate range of M. The slope of $\ln \alpha$ in equation (2) is then

$$B = Q/8a[D(M_1) - \gamma M_1]T \quad (6)$$

The calculated values of B also match the observed to within an order of magnitude. Thus the two observed conductivity–sorption relations are manifestations of the same mechanism: conduction by ions in a medium of very low dielectric constant.

The activation energy of conduction will be the sum of the activation energy of the carrier mobility and the enthalpy change of the pairing equilibrium. The latter is the larger. Differentiating equation (4) one gets:

$$\Delta H_a = R.(Q/2aD).[1 + T(\mathrm{d}\ln a/\mathrm{d}T + \mathrm{d}\ln D/\mathrm{d}T)] \quad (7)$$

As the temperature coefficient of a will be $\sim 10^{-4}$, the term $T(\mathrm{d}\ln a/\mathrm{d}T)$ may be neglected; however, as $\mathrm{d}\ln D/\mathrm{d}T \cong 3 \times 10^{-3}$ at high frequencies[6], $T(\mathrm{d}\ln D/\mathrm{d}T) \cong 1$ in the range 0–100° C. The appropriate values of D are less than 6. Using these values and 2·8 Å. for a, the Na—Cl distance in sodium chloride[7], one obtains as a least value of the activation energy of conduction, $E_a = \Delta H_a = 20$ kcal./mole.

As the high-frequency dielectric constant is probably the correct one to use, corresponding to the rapid motion of the free ions, values of $D < 6$ will always be found. For example, carefully dried oxidized cytochrome c at 10 cycles/sec. and 100° C. has a dielectric constant of 3·1 (ref. 1). The large values of activation energy found in dry substances are therefore understandable in terms of an ionic theory of conduction.

The success of an ionic mechanism treated by the approach of King and Medley[3] in explaining two commonly observed properties of polymeric materials suggests that the conductivity of dry protein[8,9] is not unique in being electronic, but is another case of ionic conduction in polymeric substances. While a mechanism of electronic conductivity has been used with success to explain some conductivity properties of irradiated polymers[10], the conclusion reached above is that the dark conductivity is ionic, and calls for a treatment of the irradiated system from the ionic point of view.

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GEOMORPHOLOGY

Involutions and Ice-Wedges in Devon

Relict periglacial phenomena have been recorded from south-west England for more than two hundred years. Reference has been made to head, clitter, rubble drift, loessic deposits and other manifestations of mechanical rock-weathering and ablation of debris under sub-arctic conditions[1], to geomorphological features which resemble actively developing tundra land-forms[2] and to fossil floras with arctic or alpine characters[3]. But so far as has been ascertained, no account has been given of phenomena which attest to the former existence of frozen ground (tjäle) in Devon.

An instructive illustration of involutions[4] is provided by a disused 'gravel' pit in decomposed, hydrothermally altered (tourmalinized) granite at 1,380 ft. O.D. on the gently sloping ($< 2°$) Cowsic/Blackbrook interfluve 1 mile west of Two Bridges, Dartmoor (*SX*/596752). The pit sections show up to 2·0 m. of decomposed granite (growan) and head on an uneven base from which open-jointed masses of sound rock project tor-like into the incoherent material. The highly irregular boundary between the brown, gravelly and gritty head of relatively fresh crystal and rock fragments and the underlying, paler growan with its characteristic flecks of white, decomposed felspars is emphasized, in places, by a prominent 0·5-cm. thick iron pan, a product of post-periglacial pedogenesis. But the involutions are not confined to an interdigitation of head and growan.

Fig. 1

Equally striking structures occur within the growan itself, which is disturbed to within 20 cm. of the base of the section (Fig. 1). A well-defined linear junction exists between the highly contorted growan characterized by a lineation of its altered felspars and the equally incoherent but undisturbed material in which the felspars have a random disposition as in adjacent blocks of sound granite. Thus it would appear that the lowest layer of the otherwise incompetent superficial mantle remained frozen while the overlying growan and head comprised an annual active layer or mollisol, and the involutions are expressions of the release of stresses set up during the re-freezing, from the surface downwards, of the seasonally thawed zone above the tjäle.

The example of ice-wedge pseudomorphs occurs in a pit at 450 ft. O.D. on the low western scarp of the Triassic Pebble Beds, 6 miles east of Cullompton (*ST*/066144). Unmistakable indications of frost-disturbance in the uppermost 1·0–2·0 m. of the pebble beds are provided by many exposures in the discontinuous escarpment, but it is reserved for the section in Fig. 2 to exhibit structures which are diagnostic of the former presence of the tjäle at such low elevations in Devon. The wedges penetrate up to 2·0 m. of the red, predominantly sandy, upper parts of the formation, the bedding of which is turned up sharply at their margins. They are filled with the same pale, yellowish sand that forms the bulk of the 60 cm. of head overlying the red rocks. It would seem that they were initiated as frost-cracks in frozen and thus impermeable sands and gravels, filled with melt-water from above, occupied by ice-wedges and afterwards filled with material washed in from the superjacent mollisol.

Fig. 2

A full account of these phenomena will be given elsewhere. But it may be noted that at least two distinct cryergic phases are represented at these and other sites. Thus we have evidence bearing not only on conditions during individual cold phases but also on the chronology of those Pleistocene phases during which the landscapes of south-west England experienced so profound a periglacial metamorphosis.

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CRYSTALLOGRAPHY

Crystals of Cellulose

Recently several authors have described the growth of polymer crystals from solution[1–5]. These crystals are lamellar in structure, and it has been established that the chain molecules are oriented perpendicular to the plane of the layers. Since the average chain-length considerably exceeds the thickness of the lamellæ, it has been proposed that the chain molecules must be sharply folded in the crystals[3]. In comparison with the synthetic polymers on which these observations have been made, cellulose molecules are known to be relatively inflexible and should therefore be an interesting system for similar studies. This communication gives a brief preliminary account of the growth of crystals of cellulose triacetate and their conversion to crystals of cellulose.

The cellulose triacetate used had a degree of polymerization of about 300 and an acetyl value of 44·3 per cent. The crystals were grown from solution in nitromethane with concentrations in the range 0·05–3 per cent. Crystallization was effected by supercooling the solutions. In the case of the more dilute solutions where the nucleation rate appears to be rather low, crystallization was facilitated by adding suitable amounts of a non-solvent to the solution.

The crystals were visible under the optical microscope with phase contrast or incident illumination (Fig. 1). They were square in shape, and electron microscopy has shown them to be lamellar in structure. X-ray and birefringence measurements suggest that the chain molecules are oriented normal to the plane of the lamellæ.

Deacetylation of the crystals was carried out in 2 per cent potassium hydroxide solution in aqueous methanol (50 : 50 v/v) at room temperature for about 10 hr.[6]. Following saponification, the material was washed thoroughly with water and examined in the optical microscope. The external form of the crystals was not disturbed by the reaction, although considerable shrinkage (about 30 per cent) in the lateral

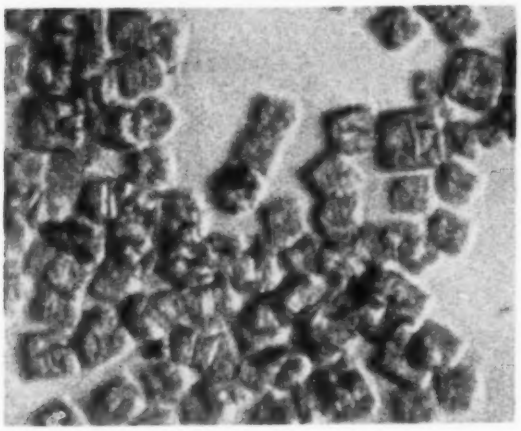

Fig. 1. Solution-grown crystals of cellulose triacetate (incident steep oblique illumination). (× 1,500)

dimensions had occurred. This contraction might possibly be accounted for on the basis of differences between the density and base molar weight of cellulose and the triacetate. The X-ray diagram (Fig. 2) of the deacetylated material shows it to have the structure of cellulose II, and indicates that the reaction had occurred throughout the lattice and not merely on the surfaces. Furthermore, optical birefringence indicates that the orientation of the chain molecules with respect to the layers was not disturbed by the deacetylation.

These observations suggest that, in spite of the relative stiffness of the molecules, folding similar to that observed in other polymers may also occur in cellulose.

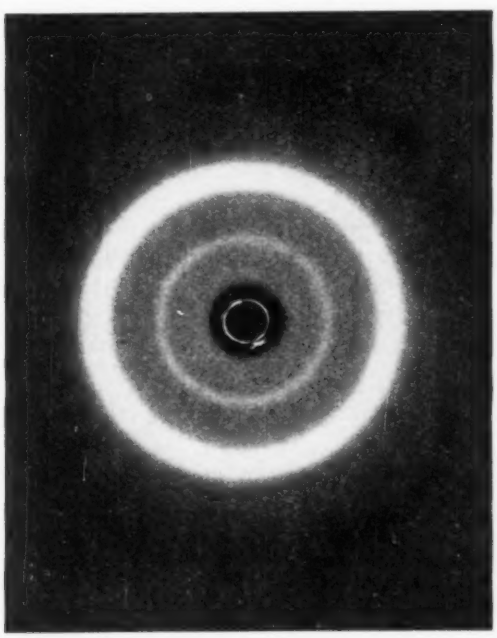

Fig. 2. X-ray diagram of deacetylated cellulose triacetate crystals

Detailed work on the morphology of these crystals is in progress and the results will be reported elsewhere.

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CHEMISTRY

Determination of Heats of Adsorption by Transient-Response Techniques

The classical equations of chromatography[1] have been applied to the determination of the heat of adsorption of a gas on a solid[2,3] by recognizing that the measured residence time, within a packed column, of a pulse of adsorbable gas relative to that of the carrier (or non-adsorbable component) may be related to an 'equilibrium constant' K_a by the equation :

$$\frac{t_c}{t_a} = \frac{1}{1 + K_a} \qquad (1)$$

where t_a and t_c represent the retention times, respectively, of the active and carrier species. By assuming that $K_a \gg 1$ and utilizing the usual temperature functionality for K_a, Greene and Pust[2] show that the logarithm of the retention time of the adsorbing component is linearly related to the reciprocal of the absolute temperature. Thus the observed data on retention time versus temperature permit the evaluation of the adsorption heat, ΔH. Good agreement between values of ΔH determined by this technique and those obtained by others calorimetrically and/or isosterically was found by Greene and Pust for the adsorption of some low boiling gases on charcoal and for light hydrocarbons on alumina and silica gel at temperatures below 100° C. However, these authors correctly noted that no simple correspondence should exist between heats of adsorption derived from continuous-flow transient-response data (adsorption chromatography in their work) and those obtained by calorimetric methods, since the latter are functions of surface coverage.

The purpose of this communication is to extend insight into the phenomenon by reviewing the fundamental equations which govern the pulse dispersion and its residence time for various well-known adsorption equilibria.

I shall consider the behaviour of a concentration pulse passing through a tube packed with solid particles capable of reversibly adsorbing the pulsed component. Travelling at an average velocity $u = u_0/f$, where f is the fractional void volume of the packed section, the pulse will be dispersed by virtue of axial diffusion[4] characterized by a coefficient, D,

and by reason of equilibrium adsorption. In terms of column-length, x, one may write[5]:

$$D\frac{\partial^2 c}{\partial x^2} - u\frac{\partial c}{\partial x} = \frac{\partial c}{\partial t} + \frac{(1-f)}{f}\frac{\partial n}{\partial t} \qquad (2)$$

where $\partial n/\partial t$ represents the transient on the solid phase and $\partial c/\partial t$ that change resulting in the gas phase due to the adsorption–desorption process. In terms of the fractional surface coverage, θ:

$$n = n_0\theta = g(K_a c) \qquad (3)$$

where n_0 is concentration of total adsorption sites, K_a is an adsorption equilibrium constant, $Be^{-\Delta H/RT}$.

A number of cases follow once the form of the equilibrium law is specified.

Case 1. *Simple Linear Equilibrium.*

$$n = n_0\theta = n_0 K_a c \qquad (4)$$

Thus:

$$\frac{\partial n}{\partial t} = n_0\frac{\partial \theta}{\partial t} = n_0 K_a\frac{\partial c}{\partial t}$$

Equation 2 becomes:

$$D\frac{\partial^2 c}{\partial x^2} - u\frac{\partial c}{\partial x} = \frac{\partial c}{\partial t}\left[1 + \frac{(1-f)}{f}K_a\right] \qquad (5)$$

Let:

$$\beta = 1/\left[1 + \frac{(1-f)}{f}K_a\right] \text{ and } Z = x - \beta u t$$

then:

$$\beta D\frac{\partial^2 c}{\partial Z^2} = \frac{\partial c}{\partial t} \qquad (6)$$

Equation 6 is readily solved[6] for the boundary conditions commensurate with a pulse input of volume V, to yield:

$$c(x,t) = \frac{V}{fA\sqrt{\pi\beta D t}}\, e^{-[x-\beta u t]^2/4\beta D t} \qquad (7)$$

where c is expressed as volume of active component per unit volume of fluid and A is the column cross-sectional area.

The mean retention time measured in terms of the pulse maximum is obtained by setting the first derivative of equation 7 equal to zero.

$$t_a = \frac{D}{\beta u^2}\left(\sqrt{1 + (xu/D)^2} - 1\right) \qquad (8)$$

When $xu/D \gg 1$ (a condition realized in beds of more than several particle diameters of length[6]), equation 8 becomes:

$$t_a = \frac{1}{\beta}\left[\frac{x}{u} - \frac{D}{u^2}\right] = \frac{t_c}{\beta} \qquad (9)$$

where the term $[x/u - D/u^2]$ is the retention time, t_c, of the carrier, since axial diffusivity, D, has been shown[6,7] to be independent of the nature of the gas so long as the Reynolds number ($D_p u/\upsilon$) is greater than 10. At Reynolds numbers less than 10, differences in molecular diffusivity, D_m, exert a negligible effect if $D_m/ux \ll 0{\cdot}1$.

In the terminology of chromatography, therefore, equation 9 is, in terms of equation 1:

$$\beta = \frac{t_c}{t_a} = \frac{1}{1 + \dfrac{(1-f)}{f}K_a} = \frac{1}{1 + K_a} \qquad (10)$$

It may be concluded that isothermal residence-time data permit a determination of K_a when the linear equilibrium prevails.

Case 2. *Freundlich Equilibrium.*

Where:

$$n = n_0\theta = n_0 K_a c^a \qquad (11)$$

Equation 2 becomes a non-linear one:

$$D\frac{\partial^2 c}{\partial x^2} - u\frac{\partial c}{\partial x} = \frac{\partial c}{\partial t}\left[1 + \left(\frac{1-f}{f}\right)K_a a c^{a-1}\right] \qquad (12)$$

Measurements of β in this circumstance are of doubtful significance since the derived 'equilibrium constant', K_a in equation 1, is obviously a function of concentration distributed in a gaussian or near-gaussian fashion.

Case 3. *Langmuir Equilibrium.*

$$n = n_0\theta = \frac{n_0 K_a c}{(1 + K_a c)} \qquad (13)$$

Equation 2 again becomes non-linear, the apparent β being:

$$\beta = \frac{1}{\left[1 + \dfrac{(1-f)}{f}(1-\theta)^2 K_a\right]} \qquad (14)$$

The direct determination of K_a by equation 1 in this instance leads to meaningless results, since surface coverage is a variable dependent on both concentration and temperature.

We may conclude that only in the circumstance where a simple linear equilibrium law prevails will a meaningful value of K_a be inferred from transient–response studies. A pseudo-linearity of the adsorption isotherm may indeed be achieved by an appropriate choice of pulse concentration. Alternatively, the relationship between residence time and pulse concentration at a given temperature may be extrapolated to zero concentration[3]. However, should the condition of linear equilibrium be realized, the significance of the derived adsorption heats demands closer examination.

If, following Boudart[8], the heat of adsorption is expressed as a function of temperature by the approximation:

$$Q = q_0 + aT \qquad (15)$$

then, even in the instance of linear equilibrium, the logarithm of retention time versus reciprocal temperature relation becomes, in terms of K_a derived from 1:

$$\ln K_a = \ln B + a/R + q_0/RT \qquad (16)$$

Thus the heat of adsorption so derived is the minimum (q_0) corresponding to high coverage. This point is of great importance in the study of chemisorption of reactants on solid catalysts as the value of chemisorption heat derived by transient techniques will have little significance in catalysis.

Referring to equation 14, it is apparent that, where Langmuir equilibrium prevails and surface coverage varies only slightly with concentration, derived values of K_a versus temperature may yield an unusually low value of the heat of adsorption since the term $(1-\theta)^2$ varies with temperature in a manner which will decrease the slope of a plot of $\ln K_a$ versus $1/T$ plot to yield a value of $q < q_0$.

I wish to acknowledge the benefits derived from discussions of this subject with Profs. Paul Emmett

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Oxidation of Chromium(II) Amines by Water

AN interest in reactive reducing agents has led us to investigate aqueous solutions of chromium(II) containing excess of polyamines. We have observed that, in the absence of oxygen, these deep blue solutions (pH > 9) evolve hydrogen in accordance with the reaction:

$$2Cr(II) + 2H_2O \rightarrow 2Cr(III) + H_2 + 2OH$$

Although the reaction is quite slow when the amine is ethylenediamine or diethylenetriamine[1], with purified triethylenetetramine or *tris*(β-aminoethyl)amine[2] the reaction is sufficiently rapid to be studied conveniently. It is apparently autocatalytic with excess of the linear tetramine, and first-order in chromium(II) when the branched amine is present.

Hydrogen evolution from rapidly stirred solutions of chromium(II) perchlorate (0·02–0·05 *M*) in 0·3 *M* *tris*(β-aminoethyl)amine (μ = 1·2) was followed manometrically; it exhibited a strong dependence on pH. At 25°, the first-order rate constant was a maximum near pH 11 (4×10^{-4} sec.$^{-1}$) and lower by a factor of 10 at pH 9·5. No reaction was observable near pH 13. When all exchangeable hydrogen in reactants and solvent was replaced by deuterium, the rate constant was slightly decreased ($1{\cdot}0 \times 10^{-4}$ to $1{\cdot}3 \times 10^{-4}$ sec.$^{-1}$ at a glass electrode pH of 10·3). In isotopically normal media saturated with deuterium gas, the reaction did not yield measurable amounts of HD.

The other product of oxidation of chromium(II) by *tris*(β-aminoethyl)amine solutions, a violet chromium(III) complex, was subjected to chromatographic analysis on a column of 'Dowex 50 × 8' cation exchanger. Although it was slowly displaced as a single band by 0·01 *M* barium hydroxide, the complex could not be eluted by 0·01 *N* sodium hydroxide or, on the acid side, by *N* perchloric acid or 0·02 *M* lanthanum perchlorate in 0·01 *N* perchloric acid. This behaviour suggested that the oxidized chromium was bound as a binuclear complex carrying a charge of +4 or more in acidic solution[3], until it was determined that *cis*-diaquo*bis*ethylenediamine cobalt(III) ion behaved similarly. The complex itself was isolated as the chloride by evaporation of the barium hydroxide eluate after precipitation of barium as the carbonate and subsequent acidification. This product had the same visible absorption spectrum as the reaction mixtures at complete reaction, maxima at 537 and 402 mμ, and gave chromium and nitrogen analyses indicating a ratio of chromium to *tris*(β-aminoethyl)amine of 1. The analytical results were not sufficiently precise to allow determination of a complete formula.

Although the observations detailed above do not suggest or rule out a mechanism for hydrogen evolution from aqueous chromium(II)–polyamine solutions, they are reported here since such evolution from homogeneous solution is uncommon.

A related observation, that chromium(II) added to a solution of *tris*(β-aminoethylamine) containing excess acrylamide is instantly oxidized to a complex different from that described, is still being investigated.

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Polarographic Behaviour of Chromium-Dipyridyl Complexes

IT has been shown previously that dipyridyl (dipy) complexes of cobalt and nickel are reduced at the dropping-mercury electrode with the formation of uni- and zero-valent complexes, respectively[1,2]. Further work led to the conclusion that iron(II) dipyridyl complex is not reduced at the dropping mercury electrode and that the complex $Mn(dipy)_3^{2+}$ is reduced with the formation of manganese(I) complex (unpublished results).

The complex $Cr(dipy)_3^{3+}$, prepared by Hein and Herzog's method[3], is reduced at the dropping-mercury electrode in three waves, the ratio of which is 1 : 1 : 1. The comparison with the wave-height of the complex $Cr(NH_3)_6^{3+}$ has shown that each of the waves of $Cr(dipy)_3^{3+}$ corresponds to the acceptance of one electron for each particle of the complex. In aqueous 0·5 *M* sodium chloride solution, the slope of the first wave is identical with that of a reversible one-electron wave. The second wave, on the other hand, has a discontinuous character and the third one is drawn out (Fig. 1). In a solution of lithium chloride in 50 per cent ethanol, the first and second waves have the shape of a reversible one-electron wave, but the third one shows a sharp beginning. Furthermore, a very small adsorption wave is observed in ethanolic solutions almost at the same potential as that at which the discontinuous wave in aqueous solution appears (Fig. 1). The half-wave potentials (measured against the saturated calomel electrode) are summarized in Table 1.

Table 1. HALF-WAVE POTENTIALS OF THE WAVES OF $Cr(dipy)_3^{3+}$ (V., 20° C.)

Solution	First wave	Second wave	Third wave
0·5 *M* Sodium chloride, water	−0·36	−0·73*	−1·38
0·5 *M* Lithium chloride, 50 per cent ethanol	−0·36	−0·71†, −0·895	−1·35*

* Discontinuous wave. † Adsorption wave.

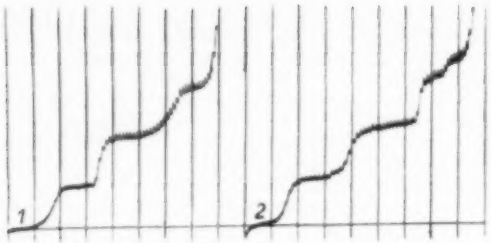

Fig. 1. The reduction of $Cr(dipy)_3^{3+}$. Curve 1, in 0·5 *M* sodium chloride (water). Curve 2, in 0·5 *M* lithium chloride, water–ethanol mixture, 1 : 1. Solution : 6×10^{-4} *M* $Cr(dipy)_3(ClO_4)_3$, from 0 V. (saturated calomel electrode), 200 mV. (absc.); nitrogen atm., $S = 1 : 70$

All three waves are diffusion currents. The addition of strong acids causes an increase of the second and third wave and the appearance of a kinetic, catalytic wave at negative potentials. This catalytic wave is formed even at very low hydrogen-ion concentrations, at which the increase of the second and third wave cannot be observed.

Using the Kalousek commutator, I have found that the product of the three-electron reduction is oxidized in three one-electron steps, the second and third being at the same potentials at which the reduction steps proceed. Similarly, the product of the two-electron reduction is reversibly oxidized in two steps and the product of the one-electron reduction in one step (Fig. 2). In experiments with the commutator in ethanol solution, the wave at $-0{\cdot}71$ V. is very pronounced, which is in agreement with its being an adsorption phenomenon.

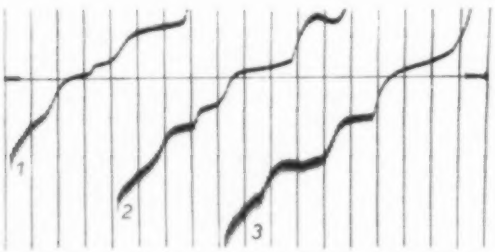

Fig. 2. Waves of complexes in lower oxidation states, generated by the commutator. Curve 1, wave of $Cr(dipy)_3^{3+}$, generated at 0·55 V. Curve 2, wave of $Cr(dipy)_3^{2+}$, generated at $-1{\cdot}15$ V. Curve 3, wave of $Cr(dipy)_3^{+}$, generated at $-1{\cdot}5$ V. Solution: 6×10^{-4} *M* $Cr(dipy)_3(ClO_4)_3$, 0·5 *M* lithium chloride in ethanol-water mixture, 1 : 1 ; from 0 V. (saturated calomel electrode), 200 mV. (absc.) nitrogen atm., $S = 1 : 150$

The results described point to the conclusion that the complex $Cr(dipy)_3^{3+}$ is reduced in succession by one-electron steps, the final product being not metallic chromium but a complex of zero-valent chromium in solution which can be re-oxidized to the trivalent complex. The reversibility of the first reduction steps shows that the reduction proceeds without any change in the configuration of the complex, so that the following scheme can be written for the whole process :

$$\underset{d_\varepsilon^3}{Cr(dipy)_3^{3+}} \rightleftharpoons \underset{d_\varepsilon^4}{Cr(dipy)_3^{2+}} \rightleftharpoons \underset{d_\varepsilon^5}{Cr(dipy)_3^{+}} \rightleftharpoons \underset{d_\varepsilon^6}{Cr(dipy)_3^{0}}$$

All complexes shown in the scheme have been prepared by Hein and Herzog[3], and their magnetic moments are in accordance with the electronic structure assigned by the letters d_ε.

The discontinuous shape of the waves is due to the formation of an insoluble reduction product. In aqueous solution the univalent and zero-valent complexes are insoluble, and hence the second wave is discontinuous. In ethanolic solution the univalent complex is soluble, but the solubility of the zero-valent complex is still very low, and accordingly the third wave has a discontinuous shape.

The first two reduction steps are reversible. The slight irreversibility of the third reduction step is probably due to the insolubility of the final product, the zero-valent complex.

The behaviour of the $Cr(dipy)_3^{3+}$ complex reported here is apparently the first known three-step reduction of a trivalent complex.

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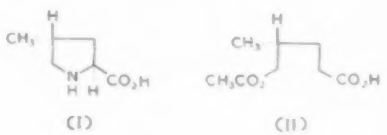
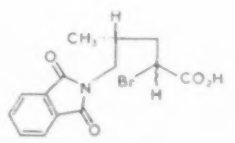
BIOCHEMISTRY

Absolute Configuration of 4-Methylproline from Perry

Two reports have appeared on the isolation of 4-methylproline from natural sources. Hulme and Arthington[1] isolated an amino-acid from apples, and tentatively assigned the structure of 4-methylproline to it as a result of elemental analysis, colour tests and chromatographic similarity to synthetic material. Later, two of us reported that hydrolysis of a peptide antibiotic yielded, *inter alia*, an amino-acid with the same chromatographic behaviour[2]. We have now been able to isolate 4-methylproline from perry (variety, Huffcap Seedling) by successive fractionation on 'Dowex-2' and 'Dowex-50' ion exchange resins. The crystalline amino-acid (8 mgm. from 5 litres of perry) has $[\alpha]_D^{ca.}$ $-52°$ (*c.*, 0·3 in water), and is rigorously identified as *trans*-4-methyl-L-proline (I) by comparison with the optically active synthetic compound obtained as follows :



(I) (II)



(III)

(+)-5-Acetoxy-4-methylpentanoic acid[3] (II) was converted by a mixture of sulphuric and hydrobromic acids to (−)-5-bromo-4-methylpentanoic acid, b.p. 114–18°/0·1 mm., the methyl ester of which, b.p. 96–100°/10 mm., condensed smoothly with potassium phthalimide to yield methyl (+)-4-methyl-

5-phthalimidopentanoate, m.p. 43–44°. Acidic hydrolysis of the methyl ester gave the acid, m.p. 73–74°, which was brominated with phosphorus and bromine to yield (+)-2-bromo-4-methyl-5-phthalimidopentanoic acid* (III), m.p. 141–42°. Vigorous acidic hydrolysis of the phthaloyl group and subsequent cyclization in aqueous sodium hydroxide furnished 4-methylproline*, m.p. 232–34° (dec.), $[\alpha]_D$ + 4 to + 12° (in water, unchanged in 5 *N* hydrochloric acid). Separation of the *trans*-L-amino-acid was achieved through the solubility of its copper salt in absolute ethanol; decomposition of the copper salt with 'Dowex-50' (NH_4^+) cation exchange resin and recrystallization of the free amino-acid to constant optical rotation yielded *trans*-4-methyl-L-proline (I), m.p. 239–41° (dec.), $[\alpha]_D$ − 59° (*c.*, 0·3 in water), $[\alpha]_D$ − 32° (*c.*, 0·5 in 5 *N* hydrochloric acid). The positive shift in optical rotation on passing from neutral to acidic solutions establishes the L-configuration of the amino-acid[4]. Since (+)-5-acetoxy-4-methylpentanoic acid (II) has been converted to (−)-α-methylglutaric acid[5] of defined absolute configuration[6], the absolute configuration (I) of the synthetic 4-methylproline follows.

The infra-red spectra of the amino-acid from perry and the synthetic product (I) are virtually identical. Together with the correspondence in specific rotation, this establishes the absolute structure (I) for the natural amino-acid. It is noteworthy that the methylproline previously isolated from an antibiotic[2], although chromatographically indistinguishable from (I), has a quite different infra-red spectrum. In this connexion, isolation of the *cis*-4-methyl-D-proline diastereoisomer from the synthetic mixture is being attempted, and the results will be published elsewhere in the full account of this work.

As proline and glutamic acid are biogenetically related[7], it is likely that naturally occurring γ-methylglutamic acid[8] has the same configuration at $C_4(\gamma)$ as *trans*-4-methyl-L-proline, and hence may be accessible from the acetoxy-acid (II). Transformation of (II) into other methyl-substituted amino-acids is therefore being investigated.

We are grateful to Glaxo Laboratories, Ltd., for a generous supply of 5-acetoxy-4-methylpentanoic acid, and to the Department of Scientific and Industrial Research for a maintenance grant (to S. D.).

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* These materials consist of approximately equal quantities of the diastereoisomers with opposite configurations at the 2-position and the same configuration at the 4-position.

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Molecular Properties of Conjugated Proteins isolated from Exudates

The protein constitution of exudates and transudates has been dealt with in a previous paper[1]. It was observed that the most peculiar property is the occurrence in the exudates of conjugated proteins with well-defined physical and physico-chemical characteristics. It has also been shown[2] that these conjugated proteins are the basis of the positivity of the Rivalta test.

In this communication the results of a preliminary investigation on the molecular properties of the conjugated proteins isolated from exudates will be reported.

These substances were isolated by dialysis of the exudate against acetate buffer at *p*H 4·5, ionic strength 0·1. A few hours afterwards a precipitate appeared at the bottom of the dialysis bag, and the precipitation was complete after 12 hr. The precipitate was collected, redissolved in phosphate buffer at *p*H 7, and again dialysed against acetate buffer at *p*H 4·5. At the end of the dialysis the precipitate was collected and analysed in the electrophoresis. At *p*H 7 two components were present: the first, about 60 per cent, had a mobility of $\mu = 6{\cdot}2 \times 10^{-5}$ cm.^{2} sec.$^{-1}$V.$^{-1}$, the second, about 40 per cent, with a mobility $\mu = 4{\cdot}5 \times 10^{-5}$ cm.^{2}sec.$^{-1}$ V.$^{-1}$, similar to that of serum-albumin. By means of a separation cell the two components were separately collected, and only the first one, that is, the largest and fastest, was shown to possess an exudative character with high positivity of the Rivalta test. The sedimentation pattern (Fig. 1) revealed that this component behaves in the ultracentrifuge as a monodisperse system, and its sedimentation coefficient, extrapolated to zero protein concentration, is $S^0_{20} = 3{\cdot}7 \times 10^{-13}$.

Fig. 1. 'Rivalta substance' isolated from serous exudate. Concentration: 1 per cent in phosphate buffer at *p*H 7. The photograph was taken 3·600 min. after reaching full speed of 59,780 r.p.m.

The diffusion constant calculated by the height/area method is $D^0_{20} = 2{\cdot}2 \times 10^{-7}$. Therefore, substituting in the Svedberg formula[3] the experimental values found for sedimentation, diffusion and partial specific volume ($\overline{V} = 0{\cdot}62$), the molecular weight was found to be $M = 108{\cdot}00$ and the frictional ratio $f/f^0 = 2$.

These results refer to a 'Rivalta substance' isolated from a serous exudate. In the case of other types of exudate, that is, hæmorrhagic or purulent, it has been observed that the molecular properties are somewhat different.

Research, now in progress, has provided clear evidence that several types of 'Rivalta substance' can be isolated, and, as previously stated, in any event

there is a correlation between some biochemical aspects of the exudate and the type of inflammation.

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Effect of Polylysine on the Absorption Spectrum of Hæmin

This is a preliminary report on a 'polybase effect' consisting of a considerable change in the spectrum of hæmin on its interaction with polylysine in alkaline solution. Two different types of complex are formed with poly-L-lysine which may be associated with the folded and unfolded structure of the peptide. These simple hæmin–polypeptide complexes are considered to serve as models for iron–porphyrin-containing enzymes, and it is hoped that they will add to our knowledge of the prosthetic group–protein interaction and of the catalytic properties connected with it.

The polybase effect on the spectrum of hæmin is illustrated in Fig. 1. (The hæmin was 6×10^{-5} *M* in this and in all other experiments reported here.) Curve 1 represents part of the visible-range spectrum of hæmin at *p*H 11, while curve 2 was obtained under identical conditions except for the presence of 6×10^{-3} monomolar poly-L-lysine (molecular weight of the order 5,000). It is evident that the polybase induces a drastic spectral change on hæmin. (Also the Soret peak of the interaction product lies at

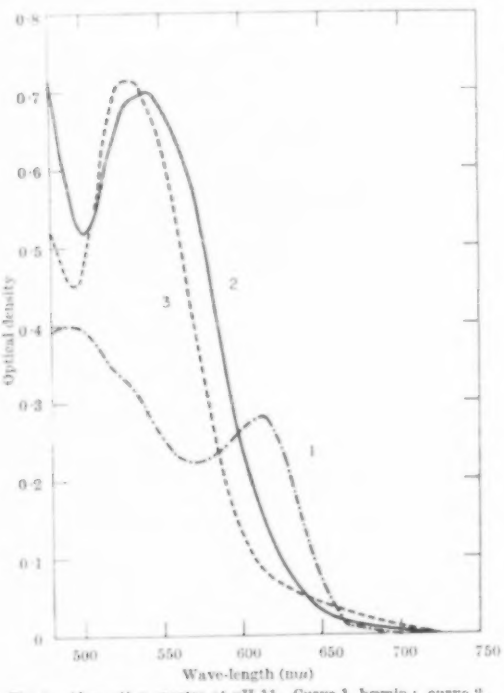

Fig. 1. Absorption spectra at *p*H 11. Curve 1, hæmin; curve 2, hæmin in the presence of poly-L-lysine; curve 3, ferricytochrome *c*

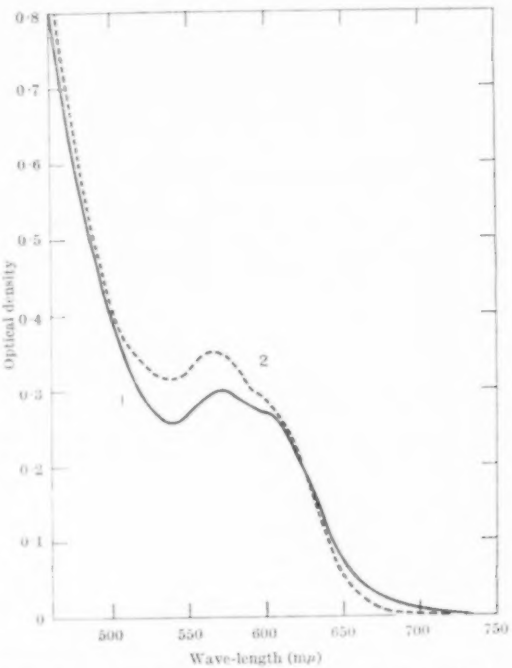

Fig. 2. Absorption spectra. Curve 1, poly-L-lysine : hæmin at *p*H 8–9; curve 2, poly-DL-lysine : hæmin at *p*H 11

420 mμ as compared to 385 mμ for hæmin.) The addition of L-lysine monomer of the same monomolar concentration as the poly-L-lysine to hæmin had little effect on the hæmin spectrum between 750 and 230 mμ. This polybase effect can be observed visually: when viewed in measuring flasks of 20–25 mm. diameter, the hæmin and L-lysine–hæmin solutions appear brown, while the poly-L-lysine–hæmin solution is red in colour.

On addition of hydrochloric acid to the red complex of poly-L-lysine with hæmin, the red colour changes to yellow-green at *p*H 9–10. Curve 1 of Fig. 2 is the measured absorption spectrum of this latter compound. Comparison with curve 2 in Fig. 1 confirms the drastic spectral change associated with this transition. (The Soret peak is at 388 mμ.) L-Lysine monomer of similar monomolar concentration again had no comparable effect on the spectrum of hæmin in the *p*H-region where the yellow-green complex is stable.

It has been shown[1] that poly-L-lysine in aqueous solution undergoes a pronounced change in optical rotation and other properties near *p*H 10. These changes have been correlated to a helix-coil transition occurring on decrease of *p*H. It would, therefore, seem reasonable to attribute the red complex described above to an interaction product of hæmin with some structurally ordered (helical) form of poly-L-lysine. Correspondingly, the yellow-green complex would be indicative of an unfolded peptide–hæmin interaction.

The following additional observations are believed to support these correlations: a sample of poly-DL-lysine of the same order of molecular weight and concentration as the poly-L-lysine used did not form the red colour with hæmin at *p*H 11, but instead showed the absorption characteristics of the yellow-

green form which was obtained with poly-L-lysine at lower *p*H only (see curve 2, Fig. 2). This result is probably due to the formation of a random rather than a helical structure in the DL-copolymer. Moreover, a very low molecular weight poly-L-lysine of the order 600 at about the same monomolar concentration did not form a complex when mixed with haemin at *p*H 11. Here, too, the absence of the red complex is probably due to the lack of suitable structure of the low molecular weight polypeptide. The folded form of the basic polypeptide apparently favours complete co-ordination to the haemin by the basic groups of the side-chains.

The spectrum of ferricytochrome *c* from horse heart (about the same concentration in mgm./ml. as the poly-L-lysine) is shown for comparison in Fig. 1, curve 3. Though the spectra of the red poly-L-lysine–haemin complex and that of ferricytochrome *c* are not identical—there appears to be a relative shift of about 10 mμ—it nevertheless seems possible to classify the cytochrome as a 'red complex' type. It would therefore be inferred that in ferricytochrome *c* the prosthetic group is bound to structurally ordered (helical) peptide over a wide range of *p*H-values (see refs. 2, 3 and 4).

It is obvious that the polylysine model compound described cannot be expected to conform in all respects to native ferricytochrome *c* and that it can only be considered to aid in our understanding of complex enzyme systems. We have found, incidentally, that poly-L-histidine forms a red haemin complex similar to that of poly-L-lysine. Its region of stability is situated at lower *p*H than that of poly-L-lysine. In addition to a peak at 530–540 mμ there is a pronounced shoulder at 560 mμ. Poly-L-glutamic acid did not show any similar effect between *p*H 5 and 11·5.

A variety of physico-chemical methods has been employed during the past decades to determine the nature of the bonds involved in linking the prosthetic group to the protein in metal-porphyrin-containing enzymes, haemoglobin and related compounds[1]. It is suggested that the differences in the spectra of the prosthetic group in these enzymes are conditioned not only by the different bond types but in some cases also by the secondary protein structure prevailing under the conditions examined. Thus the absorption spectrum of the prosthetic group–protein complex may serve as an indicator of the structural characteristics of the protein to which it is attached.

The effect of cyanide and similar small molecules acting as enzyme inhibitors on the spectrum of haemin and of iron-porphyrin-containing enzymes is well known[4], and in many cases the spectra resemble those of the red complex obtained with poly-L-lysine and haemin.

If the structural classification of the polylysine–haemin complexes described above should prove to be correct, a simple and useful tool for identification and structural characterization of basic polypeptides and perhaps of other polybases may have been found which could yield valuable data down to low concentrations.

Further investigations by different physico-chemical methods including bivalent iron compounds and various polymers and copolymers are in progress. Details of the present work and studies of the catalytic properties of some of these compounds will be published in due course.

Thanks are due to the Department of Biophysics of the Weizmann Institute for the supply of various samples of polypeptides and for the determination of their molecular weight.

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Glutamic Acid Formation by Transoximase–Oximase Reaction

IT has been previously reported that there exist in various organisms two enzymes, named transoximase[1] and oximase[2], which catalyse the transfer and reduction of the oximino group respectively. In view of the fact that glutamic acid plays an essential part in amino-acid synthesis, we have now studied glutamate formation through the combined action of these enzymes.

The enzyme solution was prepared from fresh liver of a young cockerel mainly according to the procedures for preparation *A* described in our earlier work[3] on oximase. However, the fractionation with acetone was carried out at − 10° C., and 5 gm. of the last precipitate were dissolved in 25 ml. of water at 0° C. After dialysing against cold running water for 3 hr., the solution was mixed with 8 ml. of *M*/5 phosphate buffer of *p*H 7·0 and centrifuged at 5,000 r.p.m. for 7 min. at 2° C. The supernatant contains the apoenzyme of oximase as well as of transoximase.

To measure the enzymatic actions, the following reaction mixtures were made (Table 1).

Table 1. COMPOSITIONS OF REACTION MIXTURES

Test No.	0·2 *M* α-keto-glutaric acid (ml.)	0·2 *M* acet-oxime (ml.)	0·004 per cent pyridoxal phosphate (ml.)	0·2 *M* phosphate buffer, *p*H 7 (ml.)	Enzyme solution (ml.)	Water (ml.)
1	0·5	0·5	0·5	0·5	2·0	0
2	0·5	0·5	0	0·5	2·0	0·5
3	0·5	0	0·5	0·5	2·0	0·5
4	0·5	0	0	0·5	2·0	1·0
5	0	0·5	0·5	0·5	2·0	0·5
6	0·5	0·5	0·5	0·5	2·0 (*B*)*	0

* Heated at 100° C. for 10 min.

After incubating the mixtures at 33° C. for 45 min., 1 ml. of 0·12 per cent hydrogenated diphosphopyridine nucleotide solution, 0·6 ml. of 0·01 per cent flavin adenine dinucleotide solution and 1 ml. of 0·2 *M* phosphate buffer of *p*H 7·5 were added to each of them. The last mixtures were then maintained at 33° C. for 1 hr. After the reaction, the mixtures were heated at 100° C. for 10 min., mixed with 0·1 ml. of glacial acetic acid and centrifuged at 10,000 r.p.m. for 20 min. at 2° C. 5 ml. of the supernatant were added to 2 ml. of aqueous suspensions of 'Dowex-50'. After standing at 20° C. for 10 min., the suspension was decanted three times by adding water and then centrifuged at 3,000 r.p.m. for 5 min. at 25° C. The sediment was mixed with 1 ml. of 2 per cent ammonia solution. After centrifuging at 3,000 r.p.m. for 7 min. at 25° C., the supernatant was chromatographed.

The pyridine coenzyme used was prepared by hydrogenating with alcohol dehydrogenase from yeast; its solution, therefore, contains the dehydrogenase and alcohol which cause the rehydrogenation of the coenzyme dehydrogenated during the reaction. The 'Dowex' employed was treated beforehand with 4 *N* hydrochloric acid and *N* sodium hydroxide in the usual way, and further with 2 per cent ammonia solution and 1 per cent hydrochloric acid. After washing with water, the resin was suspended in water.

To estimate the amount of glutamic acid formed, 0·05 ml. of the ammoniacal supernatant was spotted in a width of 15 mm. on a Tōyō No. 2 filter-paper and developed with a butanol–acetic acid–water (4 : 1 : 2) solvent. At the same time, a guide spot was made with a standard glutamate solution. The filter paper was then sprayed with a 0·2 per cent ninhydrin solution. The coloured portion corresponding to R_F 0·32 was cut off, extracted with 4·5 ml. of 75 per cent alcohol, and the absorption ($-\log T$) at 570 mμ was measured with a Hitachi-electric spectrophotometer. The total quantity of glutamic acid produced in each reaction mixture was calculated from a standard curve established under our experimental conditions (Table 2).

Table 2. Amount of Glutamic Acid Produced

Test No.	1	2	3	4	5	6
Glutamic acid (mgm.)	1·17	0·78	0·62	0·52	0	0

The results obtained show clearly that glutamic acid is formed from acetoxime and α-ketoglutaric acid by the action of transoximase and oximase. It was observed in the control that the amount of α-ketoglutaric oxime produced by spontaneous transoximation[4] is less than the lowest limit which can be detected by this chromatographic method.

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Replication of Deoxyribonucleic Acid in Non-dividing Bacteria

Deoxyribonucleic acid (DNA) is thought to be formed by replication. Meselson and Stahl[1] have used a density-gradient centrifugation technique to show that bacterial DNA is bipartite as was proposed by Watson and Crick[2] and that it reproduces in a semi-conservative fashion[3], each original sub-unit being found associated, on replication, with a newly formed sub-unit.

In the course of work on spontaneous mutation in non-dividing *Escherichia coli*, the possibility has been considered that errors may arise during DNA replication[4]. Although it is still a question whether such replication may account quantitatively for the mutations observed, it is clear that it does occur. Two systems of non-dividing *E. coli* have been employed in which there is a net increase of DNA but not of protein; they involve the starvation of histidineless auxotrophs for the amino-acid they require in the presence and absence of chloramphenicol.

E. coli 15 *h*⁻(histidineless) were grown at 37° C. with shaking in a salts-glucose medium[5] to which $^{15}NH_4Cl$ was added as the sole source of nitrogen together with ^{14}N-L-histidine-hydrochloride (25 μgm. per ml.). Stationary phase cells which had ceased growth due to the exhaustion of glucose after 16-hr. incubation with shaking at 37° were harvested by centrifugation and washed twice with saline. These washed cells were transferred into nitrogen-14-salts-glucose medium with chloramphenicol (20 μgm. per ml.) but no histidine; aliquots were withdrawn at intervals up to 120 min. Estimations of DNA, RNA and protein were made by the diphenylamine, orcinol and Folin methods, respectively. As Table 1 shows, DNA increased by 79 per cent while RNA more than doubled; the change in the amount of protein was negligible and the number of viable cells remained constant.

Table 1. Synthesis of DNA, RNA and Protein of *E. coli* 15 h⁻ in a Histidine-Starvation Medium in the Presence of Chloramphenicol

Time of incubation (min.)	No. of viable cells (per ml.)	Relative amount per ml.		
		DNA	RNA	Protein
0	$3·4 \times 10^8$	100	100	100
40	$3·5 \times 10^8$	169	188	103
80	$3·2 \times 10^8$	176	222	103
120	$3·2 \times 10^8$	179	224	103

This DNA, formed in non-dividing cells without a concomitant net synthesis of protein, was investigated by the method of density-gradient centrifugation. The procedures for making the bacterial lysate by sodium dodecylsulphate and for centrifugation in a cæsium chloride solution were those described by Meselson and Stahl[1]. The ultra-violet absorption photographs of the equilibrated DNA (24 hr. at 44,770 r.p.m.) of the sample taken from the culture at 120 min. showed a well-defined ^{15}N–^{14}N hybrid DNA band together with a diminished ^{15}N–DNA band which had been observed as the sole band at zero time (Fig. 1).

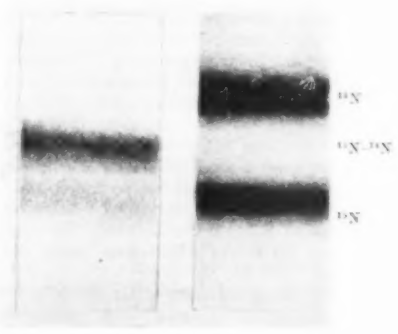

Fig. 1. Ultra-violet absorption photographs showing the DNA bands resulting from density-gradient centrifugation of: *A*, a lysate of *E. coli* 15 h⁻ labelled with nitrogen-15 taken after 120 min. incubation with chloramphenicol but no histidine in nitrogen-14 medium; *B*, a mixture of equal parts of lysates of *E. coli* 15 h⁻ labelled with nitrogen-15 and with nitrogen-14

A similar observation was made with *E. coli* 15 *t*$^{-}$*h*$^{-}$ (thymine- and histidine-less). Cells labelled with nitrogen-15, grown in nitrogen-15-salts-glucose medium supplemented with ^{15}N-thymine (5 μgm. per ml., prepared from nitrogen-15-labelled cells of *E. coli* 15) and ^{15}N-L-histidine-hydrochloride (10 μgm. per ml.), were washed and transferred into nitrogen-14 medium with nitrogen-14-thymine, but no histidine, and incubated at 37° C. with shaking. After 120 min., DNA and RNA increased by 75 and 30 per cent, respectively, while the amount of protein and the viable cell number remained constant ($1 \cdot 5 \times 10^8$ per ml.)[6]. The sample taken after 120-min. incubation showed an intense ^{15}N–^{14}N hybrid band of DNA and a light ^{15}N–DNA band in the ultra-violet absorption photograph taken following density gradient centrifugation.

From these observations it is concluded that DNA formation involves replication in non-dividing, as well as in dividing, cells. This suggests the normality of the DNA formed without accompanying protein synthesis, which has been confirmed on biological grounds[7].

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Bovine Submaxillary Mucin

A CONVENIENT method for the isolation of bovine submaxillary mucin in a relatively undegraded and homogeneous state compared to earlier methods[1] has been developed in this Laboratory. Fresh glands (640 gm.) were ground and stirred mechanically with three changes of 500 ml. of cold water for a total of 54 hr. The pooled extracts were clarified by centrifuging at 26,360*g* for 30 min. and adjusted to *p*H 3·5. The resulting mucin clot was separated and dissolved in cold water by neutralization to 7·5, and lyophilized. The product was purified by solution in 500 ml. of cold 50 per cent (w/v) aqueous calcium chloride. After centrifugation at 26,360*g* for 30 min., the supernatant was fractionated with cold ethanol. The fraction separating at 60–75 per cent (v/v) ethanol was collected by centrifugation at 26,360*g* for 30 min., dissolved in water, dialysed against water and lyophilized. All procedures were carried out at 0–4° C. The yield was 0·64 and 2·5 per cent of the glands on fresh and dry weight basis, respectively. The recovery of sialic acid was 36 and 60 per cent of that in the extract and mucin clot, respectively. A repetition of the procedure did not alter the composition of the product. The lyophilized powder could be stored at 2–4° C. without change of its properties.

The mucin was soluble in water and gave clear, colourless, viscous solutions. The solutions (0·5 per cent) gave single peaks on electrophoresis and ultracentrifugation at *p*H 7·4 and 11·3. The electrophoretic mobility was $-6 \cdot 7 \times 10^{-5}$ cm.^{2} sec.$^{-1}$ V.$^{-1}$ in phosphate buffer, *p*H 7·4 and ionic strength 0·1. The sedimentation constant ($S_{20,w}$) was 2·6 at 0·5 per cent in the same buffer. No decrease in relative viscosity was observed when that of the product was compared with that of the extract at the same concentration of sialic acid. The intrinsic viscosity of the product in phosphate buffer, *p*H 7·4 and ionic strength 0·1, was 13·4 dl./gm. The mucin contained 9·2 per cent nitrogen, 28 per cent sialic acid, 24 per cent hexosamine (as N-acetylgalactosamine), 2 per cent neutral sugars (as D-galactose), and 37 per cent protein. D-Galactose and L-fucose were the only neutral sugars detected on paper chromatograms. Tyrosine and sulphur-containing amino-acids were not found on the chromatograms.

The mucin (1 gm. in 200 ml.) at *p*H 7·4 was incubated at 37° C. with 50 mgm. of crystalline trypsin. A reduction of the viscosity to that of the solvent occurred within a few minutes. After 24 hr. the digest was dialysed with only a slight loss in protein. The tryptic digestion was repeated and the mucin was recovered from the digest by precipitation with ethanol in the presence of 5 per cent (w/v) calcium chloride. After a reprecipitation the final product was dissolved in water, dialysed, and then lyophilized. The yield was 80 per cent. Its electrophoretic pattern showed a single peak at *p*H 11·3 with unchanged mobility. It contained 8·7 per cent nitrogen, 31 per cent sialic acid, 27 per cent hexosamine, 2·5 per cent neutral sugars, and 32 per cent protein. The relative viscosity of a 0·5 per cent solution in phosphate buffer, *p*H 7·4 and ionic strength 0·1, was 1·16. These results indicate that the protein occupies an integral part of the mucin molecule and also is associated with its rheological characteristics.

An aqueous solution of the undigested mucin (1 per cent) was heated at 100° C. with hydrochloric acid. Nearly all the sialic acid became dialysable after treatment at *p*H 2·5 for 30 min., whereas practically no hexosamine was liberated. After 120 min., the hexosamine lost by dialysis was about 25 per cent, and no loss of protein was observed.

These results are compatible with one of the earlier structures proposed by Gottschalk[2] of a protein core surrounded with N-acetylgalactosamine units with all sialic acid as external end-groups.

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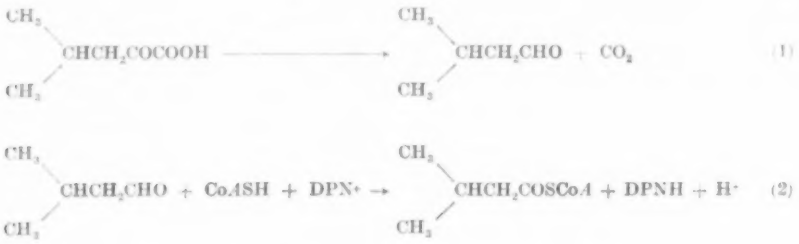
Degradative Pathway of L-Leucine in *Proteus vulgaris*

It was reported by Coon *et al.*[1-4] that in the metabolic pathway of L-leucine, *iso*valeryl coenzyme *A* was formed from α-keto*iso*caproic acid, a deaminated product of leucine, in the presence of coenzyme *A* (Co*A*), etc. I postulate that this reaction involves the following two steps:



(1)

(2)

In this communication it is reported that a cell-free extract which catalyses the reaction (1) was obtained from *Proteus vulgaris*.

Proteus vulgaris was cultivated at 37° C. for 18 hr. on peptone–broth agar slant. The cells were harvested, washed three times with de-ionized water, and suspended in 2×10^{-2} *M* phosphate buffer, *p*H 7·2. The washed cell suspension was disrupted by sonic oscillation in a Kubota vibrator, 10 kc./s., for 10 min. After centrifugation the supernatant was made 100 per cent saturated with respect to ammonium sulphate. The precipitate was dialysed against running water. In some cases, this dialysed protein solution was further fractionated with ammonium sulphate or cold acetone.

α-Keto*iso*caproic acid, used in the experiments, was prepared by extracting with acidic ether from the reaction mixture in which L-leucine was deaminated oxidatively by *P. vulgaris*. The melting point of the 2,4-dinitrophenylhydrazone of this keto-acid was 140–143° C. In this ether extract no other compound was detected by paper chromatography.

Carbon dioxide output was determined by the conventional Warburg method. The reaction mixture consisted of the following in a final volume of 2·5 ml.: $1{\cdot}67 \times 10^{-1}$ *M* acetate buffer at *p*H 5·0, 0·5 ml.; 5×10^{-3} *M* magnesium sulphate, 0·25 ml.; 2×10^{-1} *M* α-keto*iso*caproate, 0·125 ml.; and enzyme, 1 mgm. protein. This reaction was carried out at 30° C. for 10 min.

The reaction of decarboxylation proceeded in nitrogen gas as well as in air ($Q_{CO_2}^{N_2}$ and $Q_{CO_2}^{Air}$ values were 1,158 and 1,207, respectively). The optimal *p*H was 5·0, and optimal substrate concentration was found to be 1×10^{-2} *M*; half maximal activity was obtained with $1{\cdot}5 \times 10^{-3}$ *M*. Though it is not yet clear whether the reaction requires co-factors, coenzyme *A*, adenosine triphosphate, diphosphothiamine and Mg^{2+} were not required in the case of this crude enzyme.

Moreover, the reaction products were identified with paper chromatography. Three reaction systems were made as follows: (*a*) complete system (same as above experiments); (*b*) control system in which the enzyme was omitted; and (*c*) control system in which the substrate was omitted. The volume of each reaction mixture was 10 ml. Immediately after incubation for 40 min. at 30° C., 0·5 ml. of mercuric acetate (5×10^{-1} *M*) was dropped in the reaction mixture. After the precipitate was discarded, 2,4-dinitrophenylhydrazine solution was added and stored at room temperature overnight. 2,4-Dinitrophenylhydrazone formed was washed thoroughly with hydrochloric acid, and dissolved with ether. The ether solution was used for paper chromatography. In experiment *c* no precipitate was formed. 2,4-Dinitrophenylhydrazone formed from experiments *a* and *b* and *iso*valeroaldehyde solution were developed with phenol (with 20 per cent water), *iso*amyl alcohol, and *n*-propyl alcohol as solvent, respectively. The results were represented in Table 1.

Table 1

Solvent	R_F value		
	Exp. *a*	Exp. *b*	Hydrazone of *iso*-valeroaldehyde
Phenol	1·00	0·81	1·00
*Iso*amyl alcohol	0·92	0·83	0·92
n-Propyl alcohol	0·91	0·82 ~ 0·73	0·94

As shown in Table 1, one spot was obtained in experiment *a*, and the spot had the same R_F value of the hydrazone of *iso*valeroaldehyde. Furthermore, these spots were eluted from the paper with 15 per cent potassium hydroxide solution and were examined spectrophotometrically. It was concluded that *iso*valeroaldehyde was formed from this reaction system. The results reported in this communication and other experiments in which α-keto*iso*caproate was oxidized after vigorous decarboxylation, and reduced 2,6-dichlorophenolindophenol or methylene blue by this enzyme system in the presence of coenzyme *A* (and adenosine triphosphate and diphosphopyridine nucleotide), indicate that α-keto*iso*caproate was metabolized via *iso*valeroaldehyde (reaction (1)), and probably via reaction (2). Attempts at solving the latter reaction are in progress. Further details of this work will be published elsewhere.

I wish to thank Prof. S. Usami for his advice throughout the progress of this work.

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N-Ethyl-L-Asparagine : a New Amino-Acid Amide from *Ecballium*

MANY new amino- and imino-acids have been identified recently as plant constituents. A number of these newer compounds can be regarded as derivatives of either glutamic acid or glutamine, in which substituents occur on the carboxyl, amino or amido groups, or on the β- or γ-carbon atoms. The related compounds, aspartic acid and asparagine, are not known to form an analogous, extensive range of substituted derivatives. Now, however, *N*-ethyl-asparagine has been isolated from *Ecballium elaterium* (the squirting cucumber). Its relationship to theanine (II), isolated by Sakato[1] from tea leaves, is seen below :

$(C_2H_5)HNOC.CH_2.CH(NH_2).CO_2H$
N-Ethyl-L-β-asparagine (I)

$(C_2H_5)HNOC.CH_2.CH_2.CH(NH_2).CO_2H$
N-Ethyl-L-γ-glutamine (II)

The new amide was first recognized as an unidentified, reddish-brown coloured spot (*U*, Fig. 1) present on a ninhydrin-treated, two-dimensional chromatogram of a 75 per cent (v/v) ethanol extract of the aerial portions of *Ecballium*. The amide gives a colour reaction with ninhydrin that is identical with that produced by asparagine under the same conditions. The compound occupies a position close to that of proline on two-dimensional paper chromatograms developed in phenol-ammonia, followed by *n*-butanol–acetic acid–water. The R_F in the latter solvent is very sensitive to variations in temperature ; at 10–15°, the amide has an $R_{Alanine}$ value of about 1·2, whereas at 25–30°, the $R_{Alanine}$ value may be as low as 0·92.

The amide was isolated from 4·5 kgm. of *Ecballium* material. The extract was first fractionated on cation-exchange resin columns ('Zeokarb 215' and 'Dowex 50') and then further purified by chromatography on washed sheets of Whatman No. 3 *MM* filter-paper. About 1 gm. of crude isolate was obtained, which gave 300 mgm. of chromatographically pure amide after recrystallization from 75 per cent (v/v) ethanol. The isolate had the following elementary analysis : C, 45·2 per cent ; H, 7·7 per cent ; N, 17·6 per cent. $C_6H_{12}N_2O_3$ (*N*-ethyl-asparagine) requires : C, 45·0 per cent ; H, 7·6 per cent ; N, 17·5 per cent.

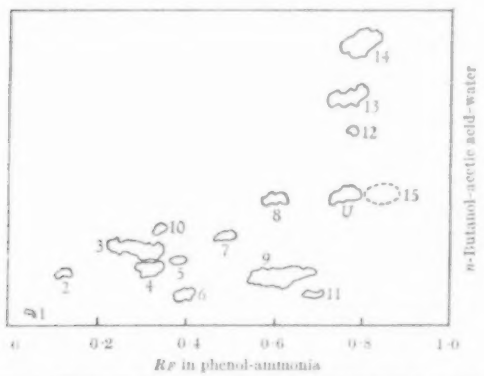

Fig. 1. Diagrammatic representation of a chromatogram prepared from an extract of *Ecballium*. The spots are : 1, cysteic acid ; 2, aspartic acid ; 3, glutamic acid ; 4, serine ; 5, glycine ; 6, asparagine ; 7, threonine ; 8, alanine ; 9, glutamine ; 10, α-aminoadipic acid ; 11, basic amino-acid ; 12, γ-aminobutyric acid ; 13, valine ; 14, leucines ; 15, position normally occupied by proline ; *U*, *N*-ethylasparagine

After hydrolysis with 6 *N* hydrochloric acid for 24 hr. at 100°, the amide was decomposed completely to yield aspartic acid and ethylamine hydrochloride. Assuming the structure (I), one mole of the isolate gave 0·96 mole of aspartic acid, and 0·98 mole of ethylamine. Aspartic acid was identified by comparison with an authentic sample by paper chromatography in four solvent systems (*n*-butanol–acetic acid–water mixture, 70 per cent (v/v) *n*-propanol, phenol–ammonia, and the upper phase of a mixture of ethyl acetate–pyridine–water, 2 : 1 : 2 parts by volume). Ethylamine, which was volatile in alkaline solution, was only chromatographed in the first two solvents and then as the hydrochloride.

The structure (I) was proved by comparison with synthetic material. After catalytic hydrogenation of N^2-benzyl-*N*-ethyl-DL-β-asparagine (kindly supplied by Dr. Liwschitz[2]), the main product, *N*-ethyl-DL-β-asparagine, was shown to be chromatographically identical with the isolated material in the above four solvent systems. The desired stereoisomer was prepared from L-aspartic acid, following the method of Hashizume[3]. β-Ethylaspartate, prepared by treating a suspension of aspartic acid in ethanol with dry hydrogen chloride at laboratory temperatures, was condensed with ethylamine, dissolved in a small quantity of ethanol, in a sealed tube at 100°. *N*-Ethyl-L-β-asparagine was separated from by-products by paper chromatography, and had the following analysis : C, 44·0 per cent ; H, 7·7 per cent ; N, 17·2 per cent.

The synthetic and isolated materials had the same melting point, 243° (decomp.), under identical conditions of very slow heating. The specific rotation in aqueous solution (*c*, 2·0 per cent) was also the same for both substances, $[\alpha]_D^{20°} - 5°$.

The natural and synthetic amides had infra-red spectra possessing identical absorption peaks (Fig. 2).

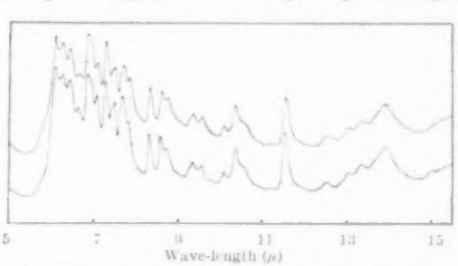

Fig. 2. The infra-red spectra of 'Nujol' mulls of *N*-ethyl-L-β-asparagine, (*A*) synthetic, (*B*) natural compound from *Ecballium*

The properties observed for the isolate confirm that it possesses structure (I) above, and so, more than 150 years after asparagine was first isolated from plant material[4], a naturally occurring derivative of the amide is now established.

Paper chromatographic evidence indicates that the amide is also present in the leaves of *Bryonia dioica* ; but it could not be detected in certain other Cucurbitaceae, including *Cucurbita pepo*, *Cucumis melo*, *Cucumis sativa* and *Echinocystis lobata*. An unknown spot (designated *U*131), observed in extracts of tulip leaves[5], moved to about the same position on paper chromatograms, and gave a similar reddish-brown colour after treatment with ninhydrin. Now it seems possible that this 'unknown'

was *N*-ethylasparagine. It is interesting to recall that the concentrations of *U*131 and asparagine in tulip leaves, grown at different temperatures, showed a well-defined inverse correlation; *U*131 was a more important constituent of leaves grown at 40° F., while asparagine was predominant in leaves grown at 70° F. Temperature could be affecting an equilibrium existing between asparagine and its *N*-ethyl derivative.

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PHYSIOLOGY

Release of Calcium-45 from Frog Nerves during Electrical Activity

Shanes and Bianchi[1] have demonstrated that stimulation of frog sartorius muscle accelerates the release of calcium-45 loaded on muscles, although Harris[2] had failed to observe this effect. Koketsu and Miyamoto[3] recently confirmed an increase in the output of calcium-45 during muscle activity. An important problem remains, however, whether acceleration of calcium output during activity is caused by the mechanism specific of the contractile system or actually is responsible for the electrical membrane phenomena. Hodgkin and Keynes[4] have reported that no change in calcium efflux can be detected during stimulation of squid axon, concluding that calcium movement during nervous activity is wholly inward. Furthermore, the 30-fold greater influx of calcium per impulse in muscle than in nerve despite the near equality of the resting influxes has been noted as consistent with a special role for calcium in contraction[5].

The experimental results reported here, however, clearly demonstrate that the release of calcium-45 loaded on nerve fibres apparently increases during electrical activity, suggesting that production of action potentials in muscles underlies the release of calcium at least in part. The discrepancy between the results observed with squid axon[4] and with the present material will be discussed at the end of this communication.

The present experiments were performed by using ventral- and dorsal-root nerves of bull-frog (*Rana catesbeiana*), which were dissected out together with the spinal ganglia and sciatic nerve plexus. These four preparations, isolated from a bull-frog, were tied together at the peripheral cut-end and suspended in a moist chamber. The root nerves were then immersed in Ringer's solution containing calcium-45 for 2 hr. at room temperature (24–26° C.). After washing the preparations for 20 sec. in Ringer, the time-course of the output of calcium-45 into normal Ringer was observed for 4 hr. During the procedure, the root nerves were successively immersed in a series of beakers containing 2 ml. Ringer every 20 min. Application of electrical stimulation (50/sec.) and recording of action potentials were made through electrodes placed on the sciatic nerves; stimulation was applied for 40 min. during the 120–160 min. period after collection was started. The radioactivity of each collection, and the ashed root nerves, obtained at the end of the experiment, was measured. The rate coefficient curves[1] were constructed from these data.

Fig. 1 shows examples of the rate coefficient curves obtained from two experiments, to one of which stimulation was applied. The rate coefficient seems to settle within 120 min. to an almost constant value, so that it appears that the extracellular calcium-45 emerges within, at least, 120 min. and the slowly emerging calcium-45 is attributable to that coming from the axoplasma. The acceleration of output of calcium-45, induced by stimulation, therefore must be indicating an increase in the release of calcium from the nerve fibres. Presumably, the membrane calcium is removed during active depolarization by exchanging for external monovalent ions.

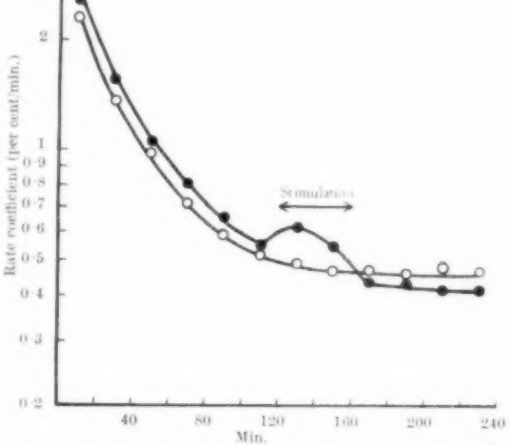

Fig. 1. Time-course of decline of rate coefficient of output of calcium-45 in Ringer. Two curves were obtained from two samples, to one of which stimulation was applied; transitory rise in coefficients on application of stimulation is readily apparent

That the increased output of calcium-45 in squid axon was not observed[4] might have been due to technical factors. In most of these experiments, radiocalcium was injected into the axon for the purpose of excluding interference from the extracellular radioactive calcium and the efflux of this tracer calcium was observed. It seems that the efflux of intracellularly injected calcium-45 may be somewhat different from the calcium efflux observed in the present experiment, since (1) the method of application differs, and (2) the membrane calcium may easily exchange with the extracellularly applied calcium-45 but may not sufficiently with that applied intracellularly. It must also be kept in mind that the material differed from those used in the present experiment.

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Significance of Membrane Calcium in Calcium-free and Potassium-rich Media

Frog Ranvier's nodes immersed in potassium-rich media are capable of producing action potentials when the membrane is hyperpolarized by anodal currents[1]. This observation was confirmed in frog sartorius muscles by one of us, who found that action potentials were restored by anodal polarization in frog sartorius muscles which depolarized in calcium-free media[2]. The so-called 'hyperpolarizing response' was also observed in muscle fibres soaked in both potassium-rich and calcium-free media. This experimental evidence seems to suggest that removal of calcium from the membrane in these two solutions might be responsible for the loss of membrane excitability, as suggested in a previous communication[2]. The rate of output of calcium-45 loaded on muscles, therefore, was studied in both calcium-free and potassium-rich solutions.

Isolated frog sartorius muscle was soaked in Ringer containing calcium-45 for 2 hr. at room temperature. After washing the muscles for 20 sec. in Ringer's solution, the time course of the output of calcium-45 into normal Ringer and the test solutions was observed for 4 hr. During this procedure, the muscle was transferred successively into beakers containing 2 c.c. Ringer every 3–20 min. for 2 hr., and the same procedure was continued for another 2 hr. using beakers containing test solutions. The radioactivity in each beaker and muscle was measured, and the time course of the output was plotted (Fig. 1).

The output of calcium-45 markedly increased when the solution was changed from Ringer to either calcium-free (particularly with ethylenediamine tetraacetic acid[3]) or potassium-rich (5–30 m*M*) Ringer[4] (Fig. 1). Such increase was precipitous and transient, suggesting the membrane phenomenon. Furthermore, the increase of the outflux was observed without detectable muscle contraction. The total amount of calcium was slightly, but apparently, reduced in these muscles (Miyamoto and Koketsu, unpublished work). If such loss of calcium is responsible for inexcitability and also for depolarization, reduction of membrane potentials in these two solutions would be less pronounced when the release of calcium is prevented in some way. Actually, no appreciable depolarization was observed when cocaine (8×10^{-4} gm./c.c.) was added to the calcium-free Ringer in which the release of calcium-45 was apparently inhibited as shown in Fig. 1. Similar results were obtained by adding magnesium[3], strontium, cobalt, or nickel ions to the calcium-free solution. Depolarization in potassium-rich solution could also be prevented by increasing the external calcium or adding these divalent cations; the increased release of calcium-45 observed in potassium-rich solution was inhibited in these cases. Similar results were also obtained by adding cocaine (1×10^{-3} gm./c.c.) to the potassium-rich solution (Fig. 1). These experiments demonstrated clearly the close parallelism between the drop of resting potential and the output of calcium-45 in both calcium-free and potassium-rich solutions.

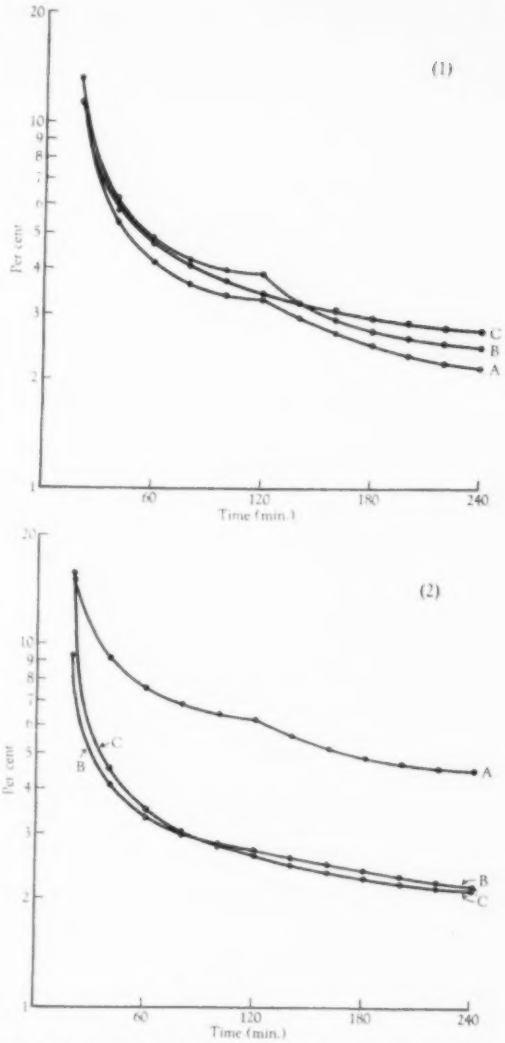

Fig. 1. Time-course of decline of calcium-45 content of individual muscles. Time-course during initial 120 min. was obtained in Ringer. After 120 min. bathing solutions were changed to test solutions: (1) *A*, calcium-free Ringer; *B*, calcium-free ethylenediamine tetraacetic acid (4 m*M*) Ringer; *C*, calcium-free Ringer containing cocaine (8×10^{-4} gm./c.c.). (2) *A*, potassium-rich (20 m*M*) Ringer; *B*, potassium-rich Ringer containing 50 m*M* calcium chloride; *C*, potassium-rich Ringer containing cocaine (1×10^{-3} gm./c.c.)

The observation[4] that the efflux of radiocalcium increases during muscle activity has been confirmed by us. The problem whether removal of calcium is

consequential[5] or actually the cause of depolarization, in calcium-free and potassium-rich media or during stimulation, seems to be crucial.

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Rapid Reduction of Portal Blood Ammonia

Ammonia is a normal constituent of portal blood[1], the concentration in the mesenteric veins draining the distal portion of the small intestine, cæcum, and upper colon being 50 per cent higher than that in the peripheral circulation[2]. Most of the ammonia in the body is produced as a consequence of bacterial action on nitrogenous substrates within the intestine[3]. Investigations with isotopically labelled urea in several species of animals have revealed that urea is hydrolysed in the alimentary tract, even when administered parenterally[4], and, in man, 0·3 gm. of urea is hydrolysed per hour, and 15–30 per cent of the urea synthesized in normal subjects is continually being destroyed[4].

Attempts to lower the ammonia concentration of peripheral blood with antibacterial agents has yielded contradictory results. No change was found in the peripheral blood ammonia in dogs treated with oxytetracycline or neomycin[5,6]. In these experiments the initial values in peripheral blood were too low to reflect any change which might be due to the antibiotics.

Oxytetracycline, but not neomycin, lowered the blood ammonia concentration in the mesenteric vein of rabbits[7]. Dogs fed uncooked horsemeat for three days exhibited marked reductions in portal blood ammonia following medication with 6 gm. neomycin; sulphasuxidine and achromycin were much less effective[8]. This variation in response is believed due to the differences in flora found in herbivores and carnivores.

The present work is concerned with rapid reductions in portal blood ammonia following administration of an intravenous combiotic to hyperammonæmic dogs, together with evidence of an *in vivo* reduction of the intestinal bacterial population during the medication period.

Forty mongrel dogs, clinically free of disease and weighing 8–10 kgm., were fed 700 gm. raw horsemeat daily for 5 days. Medication was as follows: (1) medication in diet; (*a*) 50,000 units *K* penicillin + 25 mgm. streptomycin daily for 5 days; (2) medication after laparotomy; (*b*) 60 ml. saline, (*c*) 50,000 units *K* penicillin, (*d*) 25 mgm. streptomycin and (*e*) 50,000 units *K* penicillin and 25 mgm. streptomycin. Medications given after laparotomy were contained in 60 ml. saline, and infused into the cephalic vein at the rate of 2 ml. per min.

Laparotomies were performed under pentobarbital anæsthesia, and the caudal mesenteric vein leading from the descending colon exposed. Blood samples

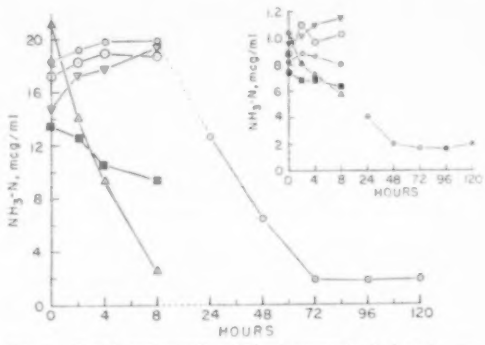

Fig. 1. Portal and peripheral blood ammonia 2, 4 and 8 hr. following intravenous medication with saline (○), streptomycin (⊠), penicillin (▽) and penicillin + streptomycin (△), or dietary supplementation with penicillin + streptomycin (○) over a 5-day interval. Each point on the graph represents the mean value for 8 dogs. Lower graph, portal blood ammonia; upper graph, peripheral blood ammonia

were withdrawn into heparinized syringes from the mesenteric and cephalic veins, prior to, and 2, 4 and 8 hr. after medication. Blood samples were obtained in a similar manner from dogs receiving antibiotics in their diet; in addition, samples were obtained at 24-hr. intervals for 5 days. Blood ammonia and urea nitrogen were determined by the microdiffusion methods of Conway[9].

Fig. 1 shows the blood ammonia concentration, and Fig. 2 the blood urea nitrogen concentration, in portal blood 0, 2, 4 and 8 hr. after medication, and in the case of dogs with combiotic in the diet at 24, 48, 72, 96 and 120 hr. after medication. On each figure are superimposed the respective peripheral blood values obtained. The advantage of using penicillin and streptomycin together lies in their synergistic action when employed in combination[10,11]. Orally administered, non-absorbable antibiotics reduce the peripheral blood ammonia in hepatic coma[12] and cirrhosis of the liver[13] only after a 1–2-day interval. The need to lessen rapidly the ammonia load on the liver, thereby keeping the tricarboxylic acid-cycle functional, makes a slow-acting agent less than optimal. The results presented here demonstrate the value of using a combination of antibiotics which act synergistically and bring about a reduction in both the peripheral and portal blood ammonia within 4–8 hr. following administration.

A combination of penicillin and streptomycin reduces markedly the numbers of viable enterococci

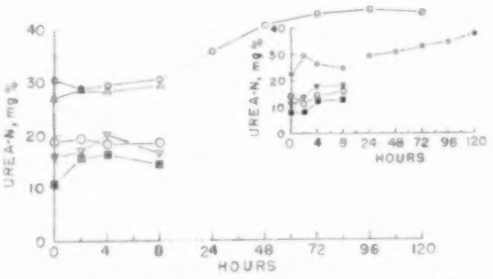

Fig. 2. Portal and peripheral blood urea nitrogen 2, 4 and 8 hr. following intravenous medication with saline (○), streptomycin (▽), penicillin (⊠) and penicillin + streptomycin (△), or dietary supplementation with penicillin + streptomycin (○). Each point on the graph represents the mean value for 8 dogs. Lower graph, portal blood urea nitrogen; upper graph, peripheral blood urea nitrogen

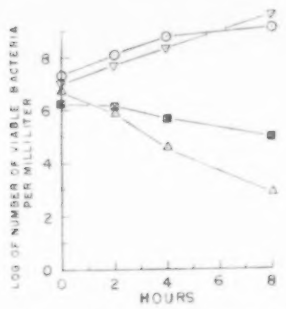

Fig. 3. Change in numbers of viable enterococci 2, 4 and 8 hr. following intravenous medication with saline (○), streptomycin (▽), penicillin (■), penicillin + streptomycin (△). Dilutions of faecal aspirate were such that each ml. of broth contained the organisms from 1 gm. of faeces

in vitro[11]; however, this has not been demonstrated to occur rapidly *in vivo*. In the present work a sample of faeces was removed from the descending colon adjacent to the area from which the blood samples were obtained for cultures in McConkey's medium. Fig. 3 shows the changes in enterococci population at intervals corresponding to those when blood samples were obtained. It is readily seen that the reduction in blood ammonia and urea nitrogen parallels the reduction in number of viable intraluminal bacteria.

Part of this work was carried out while we were assigned to the U.S. Army Medical Research and Nutrition Laboratory, Denver, Colorado. We wish to acknowledge our indebtedness to Major R. O. Linder for performing the surgical operations.

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Effect of Phentolamine on Body Fat

Several recent publications have described an increase in the level of non-esterified fatty acids in the plasma of dogs or human beings after administration of certain adrenergic blocking agents. This effect has been observed in dogs injected with dibenamine[1] and dibenzyline[2] and in human beings treated with phentolamine[3].

Work in our Laboratories with phentolamine (phentolamine hydrochloride, 'Regitine' hydrochloride, kindly supplied by Dr. F. Yonkman, Ciba Pharmaceutical Products, Inc.), several other imidazoles and related structures has shown these drugs to have an action in reducing the rate of gain in weight of the *in situ* epididymal fat bodies of immature male rats. The drugs were administered subcutaneously twice daily for a 7-day treatment period to groups of six rats weighing 55–56 gm. Rats in a control group were injected with vehicle only. Change in body-weight and food consumption were determined daily. The fresh weight of the epididymal fat bodies was determined on the morning of the eighth day. Phentolamine administered at 4, 8 and 16 mgm./kgm. doses significantly decreased the fresh weight of the fat bodies by 16, 24 and 28 per cent, respectively ($P < 0.05$), but did not significantly depress daily food consumption or gain in body-weight compared to control values. In other experiments daily food consumption was occasionally depressed.

Extension of this work led us to examine the effect of phentolamine on the extractable lipid of the carcass and adipose tissue. Three groups of five male rats weighing about 100 gm. at initiation of treatment were used. A control group was given carboxymethylcellulose vehicle (CMC) subcutaneously twice daily for a 2-week treatment period. A second group received 4 mgm./kgm. of phentolamine twice daily for 2 weeks. A third group was pair fed with the phentolamine group and received vehicle injections as in the first group. The day following the 2-week treatment period the rats were killed and the fresh weight and lipid content of the adipose tissue depots determined. Extractable lipid of the trimmed carcass was also measured. Lipid extractions were performed with chloroform/methanol (2 : 1). The results are shown in Table 1. The phentolamine-treated group showed significantly less total extractable lipid from carcass and epididymal fat bodies than either the control or pair-fed groups. The remaining intraperitoneal fat appeared to decrease in quantity but did not differ significantly from control values. Liver lipid content of phentolamine-treated rats did

Table 1. Effect of Phentolamine on Carcass and Adipose Tissue Lipids

Response	Treatment*		
	Full fed, CMC vehicle	Phentolamine (4 mgm./kgm.)	Pair fed, CMC vehicle
(*A*) Carcass Total extractable lipid (gm.)	6·2±0·2†	4·3±0·3‡	5·6±0·7
(*B*) Epididymal fat fresh weight (mgm.)	651±43	476±8·3‡	654±31
Total extractable lipid (mgm.)	420±28	276±5·5‡	394±36
(*C*) Remaining intraperitoneal fat fresh weight (mgm.)	1,150±61	930±93	1,140±24
Total extractable lipid (mgm.)	186±12	154±14	191±35
(*D*) Total body fat§ (gm.)	6·79±0·24	4·71±0·22‡	6·14±0·75

* Drug or vehicle given twice daily for two weeks.
† Mean ± *S.E.* for 5 rats.
‡ Significantly different from the full-fed control group ($P < 0.05$).
§ Includes lipid of the carcass, epididymal fat bodies and intraperitoneal adipose tissue.

not differ significantly from control (results not shown).

The extractable lipids of the carcass were further characterized by separation into saponifiable and non-saponifiable fractions. The saponifiable fractions contained 80·5 ± 4·0, 56·9 ± 3·3 and 75·2 ± 2·3 per cent of the total lipids for the full fed, phentolamine-treated and pair-fed groups, respectively. The significant decrease in concentration of saponifiable lipids of the phentolamine group suggests that neutral triglycerides are most labile.

We have also observed in preliminary experiments (Fig. 1) that the plasma concentration of non-esterified fatty acids in groups of rats treated for 1 week with phentolamine was significantly increased. This increase was greatest on the day treatment was initiated and tended to fall to control-levels from the second to seventh days. In phentolamine-treated rats the level of non-esterified fatty acids in the plasma was significantly greater than control on days 0, 2 and 4. The gain in fresh weight of the epididymal fat bodies was most depressed during the first few days after which the rate of increase in weight paralleled that of control animals. The weight of the fat bodies was significantly ($P < 0{\cdot}05$) less than control on days 2, 4 and 7.

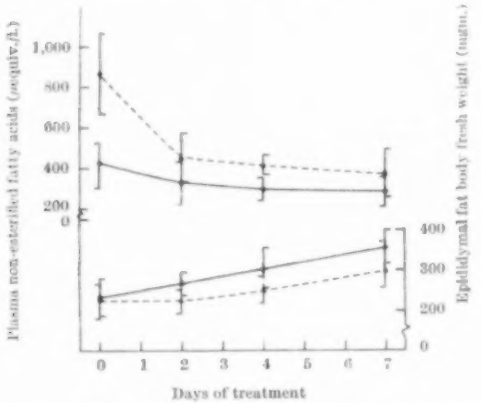

Fig. 1. Effect of phentolamine on plasma non-esterified fatty acids and the fresh weight of the epididymal fat bodies during 1 week of treatment. Determinations were made 2 hr. following the morning dose of drug on days 0, 2, 4 and 7 (6 rats per group). – – –, Phentolamine (8 mgm./kgm. twice daily); ——, control. [, 95 per cent confidence label

If phentolamine is acting to produce its effect on body-fat by some action on the autonomic nervous system, then it is possible that the observed results are secondary to catecholamine release either from the adrenal medulla or sympathetic nerve endings. Epinephrine does not appear to be implicated, however, since little or no change in blood glucose-levels has been observed by Klein and Bogdonoff[3] in humans or in our Laboratories (unpublished results) in rats. It is of interest to note that parenteral administration of phentolamine in man increased plasma norepinephrine- but not epinephrine-levels[4]. Norepinephrine increases plasma concentration of non-esterified fatty acids in man[5] and in dogs[6]. In addition, we have been successful in producing a depression of the fresh weight of the epididymal fat bodies with norepinephrine in oil using subcutaneous doses of 0·5–1·0 mgm./kgm. twice daily for 7 days. Experiments are in progress to determine the effect of phentolamine on the fresh weight of the epididymal fat bodies in adrenalectomized rats and on urinary catecholamine excretion.

This work was conducted in the Pharmacological Research Department.

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Liver and Depot Fatty Acids in Kwashiorkor

Two of the clinical features of the malnutritional state seen in tropical children and known as kwashiorkor are the marked increase of fat in the liver and the presence of depot fat in usual amounts. As the diet leading to this condition is poor in protein and fat, and contains relatively large amounts of carbohydrate, it was hoped that a study of the composition of the liver lipid might lead to a clearer understanding of the origin of this lipid. Earlier work[1] on the phospholipid, non-saponifiable and fatty acid fractions of the liver lipid in kwashiorkor showed that their proportions and degree of unsaturation were not the same as in excess liver lipid found in children who were apparently well nourished but suffering from other diseases.

To find out if the fatty acid composition of the liver lipid was also different in kwashiorkor from that in fatty livers due to other causes (control series) the lipid from post-mortem portions of liver from children aged 1–4 years was extracted with petroleum ether and the acids obtained by hydrolysis of the lipid were examined by gas chromatography. The results (mean values and *S.E.*) can be seen in Table 1, where comparable results from a similar examination of the depot fat can also be seen.

The findings are as follows: (1) There is a greater proportion of C_{18} unsaturated ($C_{18}:\Delta$) fatty acids in liver lipid in kwashiorkor. (2) There is no correlation between the proportion of $C_{18}:\Delta$ acids in the liver and the amount (gm./100 gm. liver) of liver lipid. (3) The kwashiorkor depot fat C_{14} and C_{16} acids are reduced and $C_{18}:\Delta$ fatty acids are increased. (4) No correlation exists between the portions of the various fatty acids in the depot fat and the amount of liver lipid. (5) In controls the proportions of fatty acids in the liver differ from those in the depot fat. (6) In kwashiorkor the liver lipid fatty acid com-

Table 1

		C_{12}	C_{14}	C_{16}	$C_{16}:\Delta$	$C_{18}:O$	No. examined
Lipid from:							
Liver	Kwashiorkor	Trace	3·8 ± 0·78	34·8 ± 3·14	[53·6] ± 4·69	7·8 ± 1·57	5
	Control	Trace	4·9 ± 0·10	39·7 ± 2·26	43·5 ± 1·66	11·9 ± 1·28	11
Depot	Kwashiorkor	2·9 ± 1·11	[8·3] ± 2·61	[30·0] ± 5·57	[51·6] ± 4·79	7·3 ± 0·81	4
	Control	7·9 ± 1·67	15·8 ± 1·73	44·9 ± 2·87	26·4 ± 2·80	5·1 ± 0·98	7

(Figures in square brackets indicate that when compared with control $P = < 0{\cdot}05$.)

position is very similar to that in the depots. (7) The proportions of fatty acids in the depot fat in kwashiorkor are very similar to those described in the European adult[2,3].

From these preliminary observations it seems that the fatty acid composition of the liver lipid in kwashiorkor is different from that in other types of fatty liver found in comparable children. Also in kwashiorkor the proportions of the fatty acids in the liver fat are very similar to those in the depot fat, and these in turn are very similar to values given for depot fat of normal European adults.

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Relations of Intensity of Photosynthesis and Appearance of *Piricularia oryzae* Cav. on the Rice Plant

Piricularia oryzae Cav. appears in the rice fields of Hungary in certain years, when a considerably decreased yield often occurs. However, appearance of the fungus did not cause a decrease of yield in every case. It was noted that the crop in some cases was not affected at all with the plants infected by *Piricularia*, whereas in other cases there was total damage in absence of the fungus. As a result of several years of experiment it may be stated that the fungus which, in the opinion of some workers, is the cause of browning disease ('brusone') appears only on certain soil-types. Results obtained so far of the investigation of browning disease suggest that the presence of fungi is rather a consequence of the effects and conditions of unfavourable soil and weather on the plant than connected with the browning disease proper.

Research work on the cause of browning disease led to the view that injury resulted from hydrogen sulphide formed in the water-logged soil. Hydrogen sulphide inhibits respiration and uptake of water and nutrients by the plant[1]. Since the hydrogen sulphide is removed by oxygen, we considered the problem to be practically cleared up. At the same time both the disease and the fungus were absent in years when solar radiation was abundant and the photosynthetic processes were not impeded[2].

Further experiments were carried out to elucidate the relation between browning disease, the appearance of *Piricularia oryzae* and the intensity of photosynthesis. In our experiments we used the well-known Dunghan Shali variety, which is susceptible to browning disease. As it is well known that the amount of photosynthesis is different for light of different colours, plants in the same developmental stage were exposed to different colour effects. For this purpose four iron stands (130 cm. × 130 cm. × 200 cm.) were made and covered—except for the bottom—with black, white, red, and blue linen. These frames were placed under identical conditions over plants in various phases (tillering, stem elongating, blossoming) of development each for 6 days and the changes occurring in the covered plants were observed. Before the elongation of the stem, no fungal infection could be found in any of the plants.

Following elongation of the stem, the following observations were noted: Plants under a black cover died in every case. Those under a blue cover became thin and developed no further. Under red they elongated, while the leaves of the plants under white were covered with *Piricularia oryzae*. The leaves of the plants under a red cover showed no more fungal spots than those of control plants, where they were insignificant. After removal of the white cover the fungus-spotted plants produced under it continued development and gave crop.

As regards redox potential of the soil and oxygen content of the soil water, the most favourable conditions were under the red cover.

From these observations we conclude that the synthetic processes of the rice plant under the white cover are, to a certain extent, inhibited. In the leaves, as a result of disturbed physiological processes, free amino-acids, mainly glutamin and asparagin, accumulated and rendered possible the appearance of the fungus. On the other hand, under the red cover, the undisturbed vital process of the plants developing in the abundant red light prevents the fungus from becoming established. In these experiments, fungal infection could occur only after the elongation of the stem, that is, in the generative phase when the quantity of oxygen carried to the roots decreased significantly.

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HÆMATOLOGY

Relationships between Blood Groups and the Fat Percentage of the Milk in Cattle

CATTLE show pronounced polymorphism with regard to blood groups. No less than eleven loci governing blood groups have been detected, and some of these carry very extensive numbers of multiple alleles.

Recent work[1-4] indicates the existence of relationships between some blood-group genes and characters of economic importance in cattle. Mitscherlich *et al.*[1,4] presented evidence for a negative influence of the *M* gene on total milk yield. I compared[2] the fat percentage of the milk, total fat yield and the heart-girth measurements of paternal half-sibs having and lacking certain blood-group genes belonging to eight different genetic systems. Statistically significant associations were found particularly between some blood genes and fat percentage; the latter trait having the highest heritability of the three production characters studied. Especially one of the multiple alleles at the *B* locus, namely, $B^{BO_1YD'}$, seemed to exercise a strongly positive influence on the fat percentage. Heifers carrying this allele had, on the average, a fat percentage which was 0·19 unit higher than that of their paternal half-sibs lacking this allele. Similarly the *J* gene had an increasing effect, while the *L* gene showed a negative influence on the fat percentage. A seemingly pleiotropic effect of some B alleles on the fat percentage was also reported by Neimann-Sørensen[3].

If a large number of tests are performed, statistically significant effects may be indicated even if no real biological association exists. The associations between the $B^{BO_1YD'}$, *J* and *L* blood-group genes and fat percentage found in my earlier paper have therefore been re-investigated on independent material.

Since 1955 the blood groups of all bulls used for artificial insemination in Sweden are tested. Records are now available of the daughters' fat percentage of several of these during the first lactation (305 days) and the deviation of each daughter-group from the contemporary herd averages with regard to fat percentage. These records (compiled by the bureau for progeny tests, N.A.T.) furnished material for the present study. Only those bulls were included the blood of which was tested before anything was known about the production of their progeny. For each of the blood groups studied, the bulls were divided into two classes, namely, those having and those lacking a particular blood group. For the Swedish Red and White breed (SRB) 205 bulls were studied, each having between 10 and 41 daughters (average 16·7), and in the Swedish Friesian (SLB), 77 bulls with 10–37 daughters each were analysed. The influence of the blood groups of the sires on the butter-fat test of their progeny is summarized in Table 1. For comparison the results obtained in previous work[2] on the effects of blood group genes within progeny groups are given in the right column of Table 1. The allele $B^{BO_1YD'}$ exercised a strongly positive influence on fat percentage in both the SRB and SLB breeds. Thus the fat percentage in daughter-groups from sires carrying $B^{BO_1YD'}$ exceeded that of the daughters from the remaining sires by approximately 0·10 unit. Most of the sires carrying $B^{BO_1YD'}$ were heterozygous. Slightly more than half their daughters may therefore be expected to have $B^{BO_1YD'}$. The total increasing effect of this allele on the fat percentage can therefore be estimated at about 0·20 unit. It may be recalled that in previous work carried out within progeny groups, the heifers having $B^{BO_1YD'}$ produced milk with 0·19 unit higher fat percentage than those lacking this allele.

In both the breeds the butter fat test of daughters from *J*-positive sires exceeded that of the offspring from sires lacking *J* with approximately 0·04 unit. The difference was not statistically significant within any of the breeds, but when the data on the deviation from the herd averages were pooled, a barely statistically significant effect of the *J* gene was obtained ($P \approx 0{\cdot}05$). However, no cumulative effect of the $B^{BO_1YD'}$ and *J* gene was found. In SRB the fat percentage of the daughters from the 15 sires carrying both these genes was thus almost exactly the same as in daughters from sires carrying $B^{BO_1YD'}$ only.

With regard to the *L* system finally, the results were conflicting. Within groups of paternal half-sibs of the SRB breed the *L* gene seemed to exercise

Table 1. INFLUENCE OF SOME BLOOD GROUP GENES CARRIED BY A.I. BULLS ON THE BUTTER-FAT TEST OF THEIR PROGENY*

Breed	Blood group genes	No. of sires	Fat percentage of daughters	t	Difference between progeny average and contemporary herd average	t	Weighted difference between paternal half-sibs having and lacking respectively genes (ref. 2)
SRB	With $B^{BO_1YD'}$	37	4·23	3·42‡	+ 0·11	3·66‡	+ 0·19‡
	Without $B^{BO_1YD'}$	168	4·12		+ 0·01		
	With *J*	62	4·17	1·84	+ 0·06	1·90	+ 0·08†
	Without *J*	143	4·13		+ 0·02		
	With *L*	27	4·14	0·06	+ 0·03	0·21	− 0·14†
	Without *L*	178	4·14		+ 0·03		
SLB	With $B^{BO_1YD'}$	5	4·07	2·47*	+ 0·10	2·54*	—
	Without $B^{BO_1YD'}$	70	3·96		+ 0·01		
	With *J*	14	4·01	0·98	+ 0·04	0·87	—
	Without *J*	61	3·96		+ 0·01		
	With *L*	27	4·02	2·28*	+ 0·07	2·80†	—
	Without *L*	48	3·94		− 0·02		

* $P < 0{\cdot}05$, † $P < 0{\cdot}01$, ‡ $P < 0{\cdot}001$.

a negative influence on fat percentage. However, in the present work the daughters from the SRB sires of group *L* had almost exactly the same fat percentage as the daughters from sires lacking *L*. In SLB, on the contrary, the daughters from sires of group *L* had significantly higher fat percentage than those from sires lacking *L*.

Relationships between fat percentage and blood-group genes may be due to pleiotropy or linkage. If due to relatively close linkage, results such as those obtained in the present work with regard to *L* might be possible. The fact that in three independent materials comprising two different breeds the $B^{BO_1}V^{D^c}$ and *J* genes were associated with high butter-fat tests suggests that pleiotropic relationships exist between fat percentage and the corresponding two blood groups. In the case of the $B^{BO_1}V^{D^c}$ allele the increasing influence on fat percentage seems to be so strong that selection for this allele might possibly be used to raise the fat percentage of the milk. However, before such selection can be recommended in practice, its influence on other production traits must be known.

A full account of this work will be published elsewhere.

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Hæmoglobins of Fœtal *CBA* Mice

IN man and many other species, fœtal hæmoglobin differs from the hæmoglobin of the adult, the difference being in the globin moiety and not in the prosthetic group[1]. The hæmoglobin in the blood of the new-born is often a mixture of fœtal and adult types. Adult *CBA* mouse blood can be shown, by starch gel electrophoresis, to contain at least 3 hæmoglobins (Cohen, B., personal communication). No one has, apparently, studied the fœtal hæmoglobins of *CBA* or other strains of mice.

In the present investigation, the blood of new-born and of fœtal mice was collected by decapitating the animals in heparinized saline. The red cells were washed twice in saline and finally packed by centrifuging at approximately 1,000*g* for 10 min. An equal volume of distilled water was added to lyse the cells and the cellular debris spun down. The supernatant provided the hæmoglobin samples to be investigated. Adult hæmoglobin solutions were prepared from the mother's blood in a similar manner.

The resistance of hæmoglobin to denaturation with 0·01 *N* sodium hydroxide has been investigated by Welling and van Bekkum[2], and our results on adult *CBA* hæmoglobin, observing the denaturation of diluted solutions in the spectrophotometer at 576 mμ, are comparable with their published figures. The hæmoglobins from new-born and fœtal mice were not sufficiently different from adult hæmoglobins in their resistance to the alkali to allow them to be readily distinguished: however, there appeared to be only two components in the curve for fœtal hæmoglobin while many of the samples of adult hæmoglobin showed an extra fast component. Similarly, no satisfactory differentiation could be made between these hæmoglobin solutions using the technique of oxidation to methæmoglobin with either 0·01 or 0·02 *M* sodium nitrite or with 0·0005 *M* potassium ferricyanide. The progress of the oxidation of dilute solutions of hæmoglobin was again followed at 576 mμ. Betke[3] has found that this technique could be used to characterize the human fœtal and adult hæmoglobins.

Starch-gel electrophoresis has been successful in identifying different hæmoglobin types of human[4] and mouse[5] blood. Accordingly, samples of hæmoglobins of fœtal, new-born and adult *CBA* mice were examined in this way. Particular care was taken with the early fœtal samples to ensure that no contamination of the fœtal blood with maternal or placental blood occurred. Washed and packed cell samples were lysed in their own volume of distilled water; *M*/1 phosphate buffer, *p*H 6·8, was added to double this volume and the solution centrifuged. The supernatant hæmoglobin solutions were converted to the stable cyanmethæmoglobin[6] form using potassium ferricyanide and potassium cyanide, and were then inserted into the starch gel on filter paper wicks. The Poulik discontinuous buffer system[7] was used with a current of 20–30 m.amp. at 6 V./cm. gel supplied by a low impedance, constant voltage, power pack. The current was passed for 6 hr.; the gel was then sliced and stained with a hydrogen peroxide/*o*-dianisidine solution[8]. Electrophoresis of the hæmoglobins was always carried out during the same day that the animals were killed. As can be seen from Fig. 1, the early fœtal hæmoglobins show a distinctive pattern. The samples of hæmoglobin from late fœtuses and new-born *CBA* mice were not, however, consistently different from those of the mothers. Further work on pregnancies, dated by

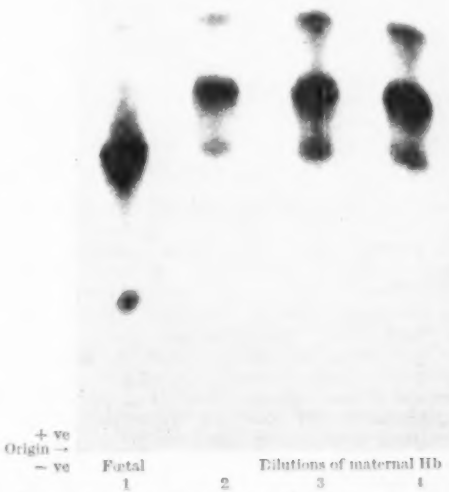

Fig. 1. Starch-gel electrophoresis (Poulik discontinuous buffer system, ref. 7) of cyanmethæmoglobins prepared from early fœtal and from three dilutions of maternal *CBA* mouse blood

vaginal plugs, showed that the early foetal pattern was seen from the twelfth to the fourteenth or fifteenth day of inter-uterine life, but that from the sixteenth day onward the adult pattern was generally obtained. The early foetal pattern differs from the adult in a diminution of the relative amounts of the fastest moving band and a predominance of the third rather than the second component. The slowest-moving band was well marked in the early foetal samples but was also present, though irregularly, in later life: the significance of this slowest band needs to be investigated further.

It can thus be seen that, in *CBA* mice, early foetal blood may be distinguished from later foetal, newborn or adult blood by the relative distribution of the different haemoglobins.

We wish to thank Mr. Bernard Cohen of the University of Glasgow for his help and advice during the course of this investigation.

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PATHOLOGY

Brain Glycogen- and Copper-Levels in Normal Sheep and Sheep affected with Scrapie

Little is known about the biochemical changes responsible for the characteristic symptoms of scrapie. We intend to examine systematically the brain and other tissues for evidence of biochemical derangements. A communication describing the lack of alteration of the serum proteins has already been published[1].

Attempts to relate disease conditions in domestic animals to those in man can be most informative. While scrapie has been likened to kuru, a disease affecting tribesmen in a localized area of New Guinea[2], we have considered, in view of the familial nature of scrapie[3], that scrapie may be related to two familial conditions in man, one a glycogen storage disease (Castaigne-Lhermitte) and the other associated with an excess of copper in certain organs (Wilson's disease)[4].

In Casteigne-Lhermitte's disease, a familial cardiomuscular variant of Von Gierke's hepato-renal glycogen storage disease, histological examination of the nervous system reveals the accumulation of glycogen within the nerve cells, varying from small droplets to confluent masses. The latter may actually displace the nucleus. This raises the question as to whether these could be confused with the neuronal vacuoles characteristic of scrapie. In individuals with the glycogen storage disease there is a motor disability characterized by muscular hypotonia. Death usually follows from bulbar paralysis or respiratory infection. Somewhat similar nervous symptoms may occur in scrapie.

Wilson's disease is a familial disease characterized by progressive rigidity, a coarse tremor of the limbs and a spastic condition of the face, mouth and pharynx with some degree of dementia in the final stages. A few cases develop in the first decade, but the onset is most common in the second decade. The disease is associated with the finding of a great excess of copper in the liver, corpus striatum, and the cornea. This is due to the failure of the serum globulins to bind copper as it is absorbed from the intestine. While there are differences in symptomatology between this disease and scrapie, the importance of copper in sheep neuropathology[5] suggested the necessity for basic information on copper-levels in sheep affected by scrapie and normal sheep.

Six sheep in which symptoms of scrapie had been experimentally induced were killed, the brains frozen within 60 min. and kept frozen until analysed. Nine normal brains from a packing house and similarly treated were used as controls.

For glycogen, 1 gm. of the frozen brain was weighed into alcoholic potassium hydroxide and hydrolysed by Kerr's method[6]. The glycogen was separated by centrifugation, taken up in trichloroacetic acid solution and analysed by the anthrone procedure described by Kahan[7].

For copper, 15 gm. of sheep brain were ashed overnight in platinum at 600° C. The residue was repeatedly digested with nitric acid, dried and returned to the muffle at 600° C. for 1 hr. until white and then made up to volume with dilute hydrochloric acid. The final determination was carried out on a suitable aliquot by Forster's method[8].

Brain glycogen values of the six sheep affected by scrapie ranged from 0·86 to 1·04 mgm./gm. of dry matter while the range for nine normal brains was 0·57–1·18. The early onset of scrapie, differences in symptomatology and the fact that brain tissue from affected sheep does not show elevated glycogen-levels indicate that scrapie is not similar to Castaigne-Lhermitte's disease.

Brain copper values of affected sheep ranged from 12·2 to 16·7 parts per million of dry matter while the range for normal brains was 13·0–35·0. The values for scrapie sheep thus fall within the lower part of the normal range. This indicates that a defect in copper metabolism is unlikely to occur in the pathogenesis of scrapie and that there is little chance of a relationship to Wilson's disease.

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Isolation of *Trypanosoma rhodesiense* from Wild *Glossina palpalis*

In an account of the epidemiology of human trypanosomiasis in south-east Uganda, Robertson and Baker[1] have referred to the momentous discovery by Bruce *et al.*[2] of the association between *Glossina palpalis fuscipes* Newstead and the devastating epidemic due to *Trypanosoma gambiense* in the early years of this century. Before the occurrence of *T. rhodesiense* Stephens and Fantham in epidemic form in 1940[3] and its persistence afterwards, sleeping sickness in south-east Uganda was due apparently to *T. gambiense* and was considered to be transmitted only by *G. palpalis*.

During the epidemic of *T. rhodesiense* MacKichan[3] recorded the first isolation of this species from *G. pallidipes* Austen in the Lugala area of south-east Uganda and afterwards other isolations of *T. rhodesiense* from *G. pallidipes* have been made[4,5]. The interesting change from *T. gambiense* sleeping sickness to that due to *T. rhodesiense* and the similarity of the epidemiological picture of both forms of the disease in south-east Uganda have been commented on by Robertson and Baker[1].

Unsuccessful attempts to isolate *T. rhodesiense* from *G. palpalis fuscipes* have been recorded[3–5]. Rennison[4] failed to isolate any *T. brucei* group trypanosomes, and of Willett's five strains, the four which were tested proved non-infective to man.

During January and February 1960, 14,500 *G. palpalis fuscipes* were collected at Lugala (0° 12′ N.; 33° 54′ E.) in south-east Uganda, and allowed to feed, not merely to probe, in batches on guinea pigs and albino rats. From these animals 21 strains of the *T. brucei* group were isolated; no other species were detected. These strains were sub-inoculated into albino rats and samples of the blood of the latter animals, killed at high parasitæmia, were frozen and stored in a dry-ice cabinet.

Morphologically all the strains were of the *T. brucei* group and were readily established in albino rats. The mean prepatent period in rats, sub-inoculated with blood from the animals in which the strains were originally isolated, was 3·9 (range 2–12) days. The parasitæmias reached 50 or more trypanosomes per high-power field in a wet preparation (4 mm. objective, × 10 ocular) in a mean of 8·6 days. The mean longevity of these infected rats was 18·0 (range 8–48) days.

The strains were tested for sensitivity to tryparsamide (B.P.) by injecting mice, at high parasitæmia, intraperitoneally with tryparsamide, at the rate of 160 mgm./kgm. on the sixth day after inoculation; the parasitæmias were little affected and none of the animals was cured.

In order to discover whether any of the 21 virulent, tryparsamide-resistant *T. brucei* group strains were in fact *T. rhodesiense* the infectivity to man had to be ascertained. It was not possible to test each strain individually, so strains were pooled and inoculated into one man as described below.

The possibility of improvement of the condition of a patient with parenchymatous neurosyphilis by fever therapy was being considered. As *T. rhodesiense* produces an acute fever and the infection is curable in its early stage with suramin (B.P.), it was considered justifiable to combine a test of these strains with this therapy. The patient had a strongly positive Kahn test and showed serious mental deterioration. He did not come from a sleeping-sickness area.

Table 1. Batches in which 21 Strains of the *Trypanosoma brucei* Group were Inoculated into Man

Batch	Strain No.	Estimated No. of trypanosomes inoculated (millions)	Site of inoculation	Chancre
A	5	8·0	Left thigh	absent
	8	38·0		
	13	27·2		
B	1	0·6	Right thigh	present
	2	63·1		
	4	4·2		
	7	15·6		
	9	14·6		
	10	8·6		
C	11	16·8	Left arm	present
	12	5·5		
	14	10·5		
	15	30·6		
	16	23·1		
	17	4·7		
D	18	13·7	Right arm	present
	19	14·6		
	20	13·3		
	21	14·3		
	22	21·3		
	23	17·6		

The 21 animals, infected each with one individual strain from the frozen material, were grouped into four batches (Table 1). To a vial of 2·5 ml. sterile heparinized Ringer's solution was added 0·1 ml. of heart blood from each member of batch *A* (Table 1). After mixing, 2·0 ml. of this suspension were inoculated subcutaneously into the patient. This procedure was repeated for each batch *B*, *C* and *D*; the inoculations were made successively on day 0 at about 2-hr. intervals at the sites designated in Table 1.

The patient was examined each morning and thick blood films were examined daily. Trypanosomes were detected in the patient's peripheral blood on day 7 before a chancre had been seen. On day 8 characteristic chancres were seen at sites *B*, *C* and *D*. On day 9 the peripheral blood was estimated to contain 420,000 trypanosomes per cu. mm. A slight pyrexia (axillary temperature, 99·2° F.) occurred on the evening of the day 7 and was followed by a continued pyrexia (axillary temperature, 102·4°–104·0° F.) from day 8 to day 9, when the patient was treated with suramin. The temperature subsided by crisis on day 10. The patient's mental condition appeared a little improved.

To summarize these observations; all the strains isolated were highly virulent to rats or mice in the laboratory and were resistant to tryparsamide. In addition, at least one of the strains produced an acute infection with a high parasitæmia in man after a short incubation period. The appearance of chancres at three of the four sites of inoculation suggested that each of batches *B*, *C* and *D* contained at least one strain infective to man.

It is concluded that among the strains there was at least one strain of *T. rhodesiense*, possibly more.

This is the first isolation of *T. rhodesiense* from wild *G. palpalis*; furthermore, it is the first isolation of a trypanosome proving infective to man from wild *G. palpalis*. Taylor's[6] presumptive evidence that the salivary infection in a *G. palpalis* at Ganawuri was *T. gambiense* is discussed by Buxton[7]. The widely held view that *G. palpalis* is only associated with *T. gambiense* sleeping sickness must clearly be re-examined.

We wish to express our appreciation of the encouragement given by Dr. W. H. R. Lumsden, director of the Organization, to epidemiological studies which have led to this result. Acknowledgment is given to Dr. P. E. C. Manson-Bahr and Mr. A. E. C. Harvey for their co-operation and help.

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RADIOBIOLOGY

Quantitative Cytochemistry using Directly Applied Radioactive Reagents

While radioactive isotopes have found valuable application in many cytochemical studies of metabolic incorporation processes, little use has so far been made of such labels in cytochemical reactions applied directly to the localization of substances in tissue specimens. Some qualitative applications to enzymic cytochemistry, for example, using metals or phosphorus-32 in deposited products, have been reported[1]. We have now examined the applicability of tritium-labelled reagents which form covalent bonds at specific sites in tissue components, as a method in quantitative cytochemistry. The advantages of such a method will include, *inter alia* (cf. ref. 2): (1) an escape from some of the problems of selectively introducing sufficient light-absorption at specific sites, since the label can be carried on many suitable simple reagent molecules; (2) autoradiographic measurement, which is free of certain of the problems of micro-spectrophotometry and is independent of the molecular environment of the target sites; (3) checks and calibrations of micro-spectrophotometric methods for the same components, and the possibility, at least in principle, of absolute determinations.

To establish the basis of the method, the acylating reagent acetic anhydride, labelled with tritium, was applied (0·4 *M*) in pyridine-acetonitrile as a general blocking agent[2], to indicate the total number of groups available to acylation, notably —NH_2, —OH and —SH groups in macro-molecules. Frog red cells (in plasma-free smears) were exposed to a layer of reagent solution in small, closed tubes. Thorough subsequent washings, in turn in unlabelled reagent, sodium acetate solution and water, removed all excess isotope. Satisfactory and reproducible autoradiographs were obtained, by the stripping film method of Pelc[4], after short film exposures (for example, 2 days, for reagent at 1·5 μc./μ*M*). The amount of isotope bound per cell increased with the reaction period, up to a maximum value (Fig. 1). Nil counts above background were found in cells similarly treated but having a prior treatment (15 hr.) with unlabelled reagent.

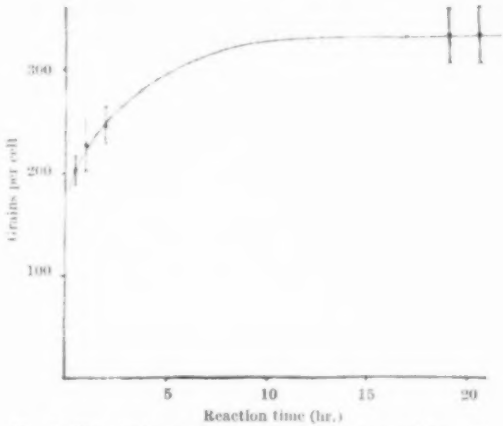

Fig. 1. Mean grain count (± *S.D.*) per cell, in normal frog red cells, after different periods of reaction

The total number of groups (N) available to this reagent in the normal frog red cell (lengths of axes in the ranges 20–23μ and 13–15μ) was found to be $5{\cdot}8 \times 10^{-13}$ mole (or $3{\cdot}5 \times 10^{11}$ groups). This is consistent with reaction at a large majority of the potential acceptor sites in the macromolecules in this cell. Such a figure is calculated from the equation:

$$N \text{ (moles per cell)} = \frac{2\, n_{max.}}{g_1 g_2 a\, t\, s},$$

where $n_{max.}$ is the maximum number of grains that can be developed per cell after treatment with reagent at specific activity s (disintegrations per min. per mole) and film exposure of t min.

g_1 and g_2 are grain-yield correction factors. g_1 is equal to the mean number of grains actually developed per activating β-particle. Multiple grain activations are betrayed by close clusters of 2 or 3 grains, and an idea of the magnitude of g_1 is obtained by scoring these as units. Such re-counting gave $g_1 = 1{\cdot}28$ (*S.E.* 0·03) which, in view of the inclusion of accidental clusters, is the upper limit. g_2 corrects for all those incident β-particles not producing grains, due to latent image fading, low energies, multiple collisions, etc. In practice, only $g_1 g_2$ is required, and this product was determined empirically by comparison of the emergent β-particle flux from a specimen (read in a gas-flow counter) with the number of grains developed in an autoradiograph of the same specimen. This ratio gave a value of 0·85 for $g_1 g_2$.

Self-absorption is represented by the absorption correction factor a. Assuming the absorption data of Fitzgerald *et al.*[3] hold here, and if the equivalent mass per unit area of the cell is known (found here by interferometry[4]), the total absorption can be obtained by an appropriate integration. This method gives $a = 0{\cdot}21$ here (that is, 21 per cent transmission). A direct determination of a was also possible, by measurement of the emergent β-particle flux from a specimen, followed by extraction and measurement (in a gas-flow counter) of the total radioactivity of that specimen. Two such experiments gave values of 0·18 and 0·19 for a. The directly determined value was preferred in calculations of N.

For comparative work, the correction factors evaluated here can be ignored, but for absolute determinations they must be investigated for each new type of material. The routine use of standard

labelled specimens, for example of acylated frog red cells as here, is useful as a means of monitoring variations in the autoradiography of other treated specimens.

Similar methods can clearly be applied with other reagents for the determination of important types of groups in various cells. We have found that the number of available protein $-NH_2$ groups can apparently be measured by use of the same reagent in cold, aqueous buffer (cf. ref. 7). With the use of unlabelled, selective blocking agents, or with the introduction of labelled acetyl into other reagents, or with the use of reagents of other types labelled with tritium (or carbon-14 or sulphur-35 where the highest resolving power is not required), the measurement of other cell components will be feasible.

A fuller account and discussion of these and related experiments will appear elsewhere. We thank Dr. S. R. Pele for discussion, and the Medical Research Council for a grant to support this work.

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Modification of Radiation Damage in Seeds by Post Treatment

In their recent paper on modification of radiation damage in dormant seeds by storage, Curtis *et al.*[1] reported that very dry barley seeds if germinated immediately after irradiation show the same damage as seeds of higher water content. The very dry seeds, however, as distinct from those of higher water content, showed a considerable storage effect, the damage increasing as the seeds are stored between irradiation and soaking. In these experiments soaking was carried out under anaerobic conditions for an initial period of 1 hr.

The existence or absence of a storage effect in irradiated seeds has been reported by many workers[2]. However, the moisture content of the seeds, which greatly influences their radiation sensitivity[3], was not controlled in most of these earlier investigations. In the remaining papers there appears to be no agreement on how the observed storage effect is related to the water content or how it is influenced by the conditions of storage and soaking. In order to shed some light on these questions, a study of the storage effect in *Vicia faba* seeds was therefore undertaken using precisely controlled experimental conditions.

The material used was *Vicia faba* var. *minor* 'Throws M.S. Winter Beans', kindly supplied from Hasler and Co., Ltd., Dunmow, Essex. The beans were stored in desiccators in single layers over sodium hydrogen sulphate or calcium chloride, the water content being measured by crushing samples of 20 and drying at 105° C. to constant weight.

Seeds of different water content were pricked and given 3,000 r. or 10,000 r. X-rays, using 200 kV., 15 m.amp., 2 mm. aluminium, 550 r./min. Irradiated seeds and controls were either soaked 4 min. after the end of irradiation for an initial 8-hr. period, or stored for 8 weeks in desiccators and then soaked. Water content was kept constant during storage. It can be shown that, after 8 hr. soaking, 90 per cent of embryos are fully soaked, whole seeds having taken up about 85 per cent of their original dry weight of water. The soaking was done in quartz-distilled water at 20 ± 1/4° C. Either air free of carbon dioxide, or nitrogen free of carbon dioxide and oxygen (purified product of Linde A.G. with oxygen content of less than 0·001 per cent, purified further by passing over catalytic copper[1]) was bubbled through the water during soaking.

Seeds were then grown in pots of moist sawdust in an incubator running at 20 ± 1/4° C. and 90–95 per cent relative air humidity. Germination was determined and root and shoot length measured 11 days after soaking. The beans were stored in darkness except for the final pricking and irradiation, and soaked and grown in darkness except for 10 min. daily at less than 20 ft.-candles. These short exposures to light should not affect the ultimate length of the shoot[5,6]. For each experimental procedure three pots of 20 beans were used. The significance of the resulting differences was tested by means of analysis of variance.

For seeds of 9·7 and 10·4 per cent water content the different conditions of soaking after irradiation had no effect on the percentage germination using either of two criteria: (*a*) visible splitting of the testa over the tip of the radicle; (*b*) root- or shoot-length longer than 0·5 cm.

Root and shoot growth results for the same experiments are summed up in Fig. 1. The root and shoot growth is expressed as a percentage of the individual controls in Table 1.

Table 1. Length of root and shoot after 11 days growth expressed as a percentage of individual controls for beans of 9·7 per cent moisture content, irradiated with either 10,000 r. or 3,000 r. and soaked immediately or after 8 weeks storage, in either nitrogenated or aerated water

Soaking time	Soaking procedure	3,000 r.		10,000 r.	
		Root	Shoot	Root	Shoot
4 min. after end of irradiation	Nitrogen	63·9	45·3	21·5	7·6
	Air	66·2	43·9	22·1	< 3
8 weeks after end of irradiation	Nitrogen	58·0	38·3	26·1	10·3
	Air	64·8	41·2	23·5	< 4

It can be seen that there was a strong effect of both irradiations on root- and shoot-length, but no clear effect of the other factors in question. Statistical analysis shows that apart from the irradiation ($P \ll 0{\cdot}001$) only moisture content gave significant differences in root and shoot length ($P = 0{\cdot}01$–$0{\cdot}001$). Seeds with 9·7 per cent humidity at zero soaking time gave slightly shorter roots and shoots than seeds with 10·4 per cent humidity. This damaging effect of drying in *Vicia faba* var. *minor* seeds was pointed out earlier[7–9]. According to the new results it appears to be significant for very small differences in water content. It should be mentioned, however, that growth reduction in the hybrid stock used here at 9·7 per cent water content was small, com-

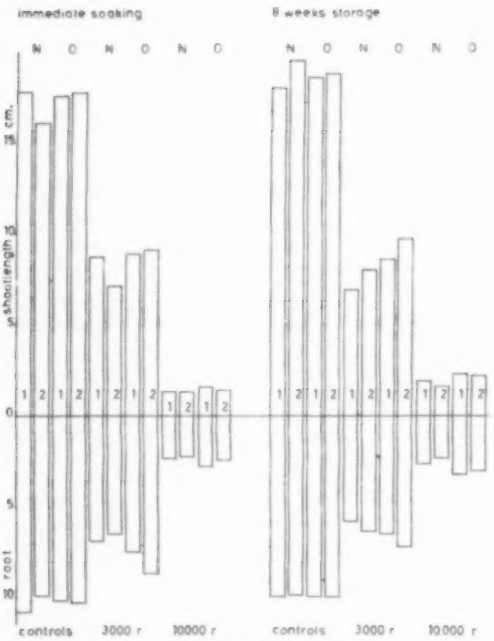

Fig. 1. Shoot- and root-length of seedlings eleven days after soaking. Seeds of two moisture contents, 9·7 per cent (1) and 10·4 per cent (2). Doses of 3,000 r. and 10,000 r. X-rays. Soaking, 4 min. or 8 weeks after end of irradiation, under aerobic (*O*) or anaerobic (*N*) conditions. Means from 60 beans in each case

pared with the earlier findings for an inbred line and that seeds of 15·1 per cent water content gave no better growth than those of 10·4 per cent.

Apart from those two effects there was no other significant effect. Neither the period of storage, nor aerobic or anaerobic soaking had any effect on the radiation damage observed, nor was any higher interaction observed between radiation and storage, or radiation, storage and soaking procedure. It should be mentioned that *Vicia* seeds of higher moisture content (12 per cent) when irradiated with 3,000 r. gave no growth reduction (experiments carried out in Southampton, unpublished), which shows that the water content used here (9·7 per cent, giving about 42 per cent growth reduction in shoots for 3,000 r.) was of the right order for *Vicia* seeds for testing the effects in question.

The above results, though at variance with those of Curtis *et al.*[1] and other workers on barley in showing no post-radiation effect of storage or of availability of oxygen during soaking, do not preclude the possibility that these effects may occur in *Vicia* under different conditions. Curtis *et al.* used barley seeds dried to very low water content; they gave higher doses and grew their seedlings in the light. However, it seems important to point out that any generalization concerning 'storage effect' and 'modification by post-treatment' is at present premature, and it is clear that further experiments of a wider scope and with other materials are necessary in order to determine the conditions under which such effects appear.

I am indebted to the Department of Scientific and Industrial Research and the Deutsche Akademische Austauschdient for a research fellowship in Great Britain, during which earlier stages of the work reported here were carried out. Sincere thanks are due to Dr. G. R. Lane of the Botany Department, University of Southampton, for valuable suggestions and constant encouragement during the period of study there, as well as for very carefully going into part of the experimental data and for help in the English manuscript. I am also indebted to Dr. L. H. Gray, Northwood, Middlesex, and to Dr. H. J. Seifert of the Chemistry Department, Giessen, for kind suggestions regarding the gases used. Irradiations were done at Southampton by Dr. J. R. Clarkson of the Royal South Hants and Southampton Hospital, at Giessen by Prof. Th. Hornykiewitsch and Dr. W. Hartung of the Medizinische Klinik der Universität. Their kind co-operation is gratefully acknowledged. The work in Giessen is supported by the Deutsche Forschungsgemeinschaft. A more detailed account will be given elsewhere.

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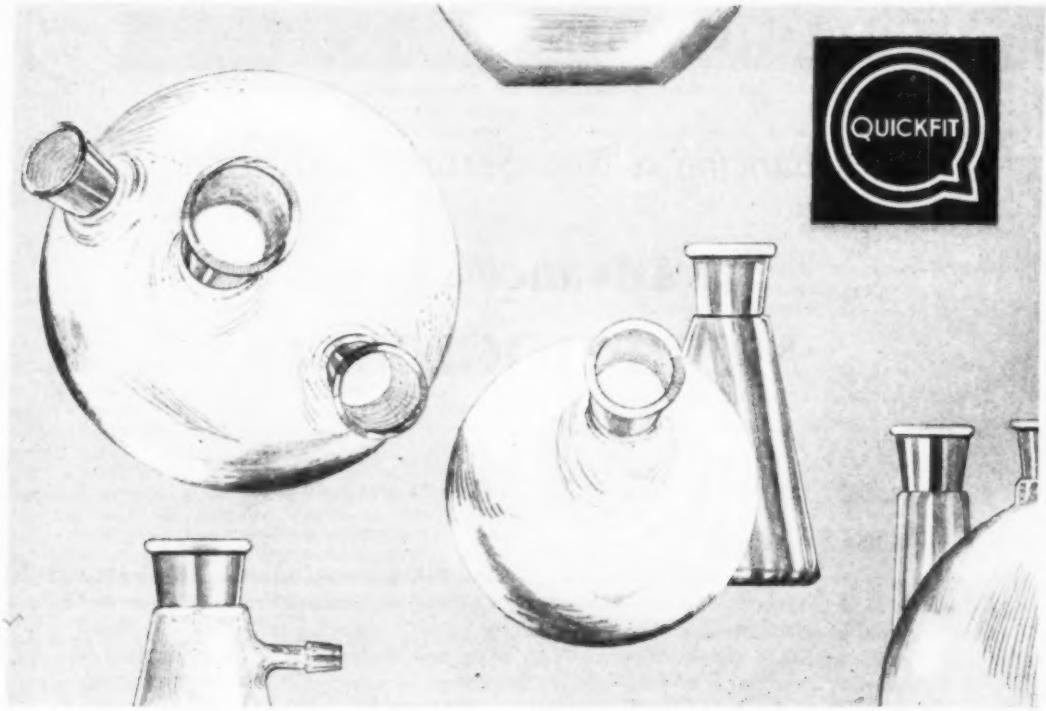
BIOLOGY

Rapid Preparation of Fresh Frozen Sections of Barley Roots

In the course of investigations of the movement of nutrient ions through barley roots, it became necessary to stop the movement instantaneously and study the distribution of the nutrient ions at that time. A technique was devised that involved stopping the reaction at liquid-nitrogen temperature and sectioning the frozen tissue for subsequent radioautography. The purpose of this communication is to report on a method of preparation of fresh frozen sections involving no prior fixation of the tissue.

The barley roots are placed in water at 0–5° C. for 1 min. They are then oriented in a slightly congealed 5 per cent gelatin mixture containing 3·5 per cent glycerine jelly. The matrix is prepared by mixing 50 c.c. of melted 10 per cent gelatin mounting medium containing 0·5 per cent carbolic acid ('Harelco'), 7 c.c. of glycerine jelly mounting medium (Brandt), and 50 c.c. of water. The mixture is allowed to cool to a soft jelly and spooned into a small embedding box that has been chilled in 'dry ice'. The roots are immediately pushed into the 'jelly', oriented and the whole embedding box placed in *iso*pentane that has been cooled by liquid nitrogen to approximately −160° C. If the drop in temperature is too rapid, the matrix blocks will often crack, and at least a minute should be allowed to bring the blocks to −160° C.

After freezing, the blocks are left at room temperature for a few minutes to allow them to be cut from the embedding boxes and then placed in a cryostat kept at approximately −22° C. When



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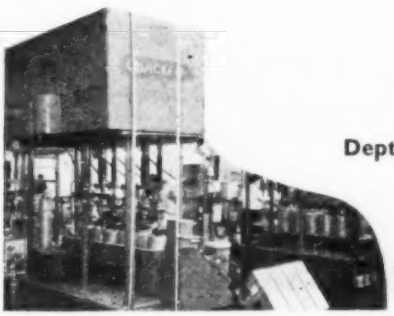

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tissue blocks are brought up to this temperature, recrystallization begins to occur, although rather slowly[1]. Nevertheless, within two days the cutting characteristics of the tissue blocks change noticeably. Very low-temperature storage is advisable if blocks are not cut within a day or two. The blocks are mounted and cut at −20° to −22° C. The Minot microtome, lubricated with 'Arctic' oil, has been satisfactory, and 16-μ sections of barley roots can be cut as a matter of routine. The use of a glass window[2,3] on the knife prevents cutting the section.

Figs. 1 and 2 show cross-sections and transverse sections of water-mounts cut according to the above procedure. The photographs were taken within fifteen minutes of the tissue being cut. There is no indication of physical alteration of the tissue during preparation or cutting. The cross-section and transverse sections are similar to the illustrations of Heimsch[4] of barley roots prepared by standard techniques involving paraffin impregnation.

After sectioning, alternate procedures are possible depending on the use to be made of the section. The section may be brushed on to a warm gelatinized slide, where melting and flattening take place at once. The sections dry very rapidly, and solutions such as water or vital dyes should be added immediately. A procedure found successful for morphological detail is to brush the section on to a warm gelatinized slide flooded with 10 per cent neutral formalin and allow it to dry at room temperature. Sections may then be stained and mounted by standard procedures. For radioautography sections may be brushed directly on to photographic plates.

One of the advantages of the present procedure is its rapidity. A sample of fresh plant tissue can be excised, frozen, cut and a section obtained on a microscope slide within an hour, depending primarily on the length of time necessary to raise the blocks from −160° to −22° C.

Another advantage is that a chemical, and to some extent physical, reaction can be stopped or slowed at any given time and the tissue examined within the hour. In our own case, we are interested in ion movement in tissue. We can stop this reaction, and by the use of radioautographs localize the presence of the ions. Other applications in chemical studies, enzyme analyses, and micro incineration are as applicable to plant tissues as to animal tissue prepared by similar techniques[5].

The present method prepares fresh frozen plant-sections involving no prior fixation or dehydration of the tissue, in contrast to other frozen tissue techniques requiring drying[6] or prior fixation. Thus, artefacts and changes occurring during tissue preparation are minimized to vanishing point.

Although the method has been used only on roots of young barley plants, it shows promise as a general method for the rapid preparation of fresh tissue sections without prior fixation.

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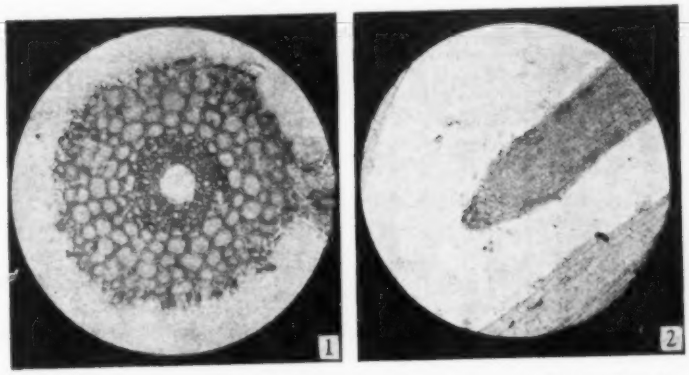

Fig. 1. Water mounts of 16-μ sections of six-day-old barley roots obtained by cutting at −22° C. a frozen gelatin block containing the roots: (1) cross-section, approximately × 400; (2) transverse sections, approximately × 150. Root tip in centre

Low-Temperature Injury in Lovegrass (*Eragrostis curvula* (Schrad) Nees)

Eragrostis curvula is a perennial bunch grass widely used in South Africa. In order to determine the low-temperature tolerance of this grass, the following experiment was carried out. Twenty dormant stools of *E. curvula* ('Ermelo' variety), cut to within 3 in. of the ground, were transplanted in the winter (May 28) of 1958 into 4-gal. tins, and watered. Ten of these tins were placed in an illuminated constant-temperature room at 31° C. (87·8° F.) on July 9. Active growth started within a day, and the plants reached a height of more than 12 in. within nineteen days. On July 28 the plants were grouped in pairs, each of which was subjected to one of the following temperatures for three days: − 16·7° C. (2° F.), − 13·3° C. (8° F.), − 12·2° C. (10° F.), − 10·8° C. (12·5° F.) and 1·7° C. (35° F.). They were then transferred to a glasshouse (at approximately 24° C. (75° F.)) for further observation. All stools had been killed by low temperature.

Of the remaining ten tins, two were placed in each of the illuminated low-temperature rooms maintained at temperatures of −16·7° C. (2° F.), −13·3° C. (8° F.), −12·2° C. (10° F.), −10·8° C. (12·5° F.) and 1·7° C. (35° F.) on July 9. On July 28 these tins were transferred to high-constant-temperature rooms (31° C. (87·8° F.)) for three days, after which they were placed in a glasshouse (approximately 24° C. (75° F.)) for further observation. Only the two plants which had previously been maintained at 1·7° C. (35° F.) resumed growth within two days, the remainder having been killed.

These observations support the views of Crider[1], who suggested that most perennial crop plants were subject to greater winter injury if previously encouraged by irrigation or other means to remain in a succulent condition until cold weather set in, and further that winter injury could not be attributed to low temperature alone.

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Effect of Polyhydric Alcohols on Frost Hardiness in Plants

In previous communications[1-3], I have reported that the increase of sugar content in a plant cell increases its frost hardiness, and that polyhydric alcohols, especially ethylene glycol and glycerol, also show the same protective action as glucose and sucrose against freezing injury in *Gardenia* leaf cells.

Recently, some attempts[4,5] have been made to determine the correlation between the seasonal fluctuations of glycerol content and frost hardiness in some insects. However, no evidence has yet been obtained to show whether the increase in polyhydric alcohols, especially in glycerol, is an important cause of frost hardening in plants or not. Therefore, the fluctuations of various polyhydric alcohols in the bark of twigs or leaves of 19 different species of woody plants were studied chromatographically in the course of both natural and artificial frost hardening. An aliquot of the extract of high concentration of polyhydric alcohols, prepared by the usual method, was developed on a filter paper, using a solvent containing *n*-butanol–water–acetic acid (4 : 1 : 2). In order to separate mannitol and sorbitol, the process was repeated five times. Quantitative analysis of three polyhydric alcohols was carried out, based on oxidation with periodate of the polyhydric alcohols eluted from the filter paper and subsequent colour reaction with a chromotropic reagent.

In winter, the glycerol content in tea, climbing spindle tree and *Platanus* ranged from 0·1 to 0·15 per cent (wet weight), while in the other 16 species its content was very small (Table 1). Furthermore, glycerol content showed only a slight change which was obviously not significant, in both seasonal and artificial hardening. Therefore, it may be safely said that glycerol does not play an important part in the frost hardening of woody plants.

In winter, the content of mannitol ranged from about 0·1 to 0·5 per cent (wet weight) in many species (Table 1). Sorbitol content amounted to about 1 per cent in the apple tree (twig bark), *Gardenia* (leaf), pomegranate (twig bark) and mountain ash (twig bark), but its content is very small in the other 15 species (Table 1). In winter the contents of mannitol and sorbitol in many species increased 2–3 times as much as in August; but in the mulberry tree they were reduced to a half the summer value. From summer to winter, the increase of total polyhydric alcohols in bark of twig of apple tree was about 38 per cent of that of total sugars during that period, but the values of all other 6 species used were less than about 7 per cent.

The total content of polyhydric alcohols in the pomegranate (bark), *Gardenia* (leaf), apple tree (bark) and mountain ash (bark) in winter ranged from about 40 to 55 per cent of the total sugar content, but in the other 15 species it does not amount to more than 12 per cent (Table 1).

In artificial hardening in early October, when such hardening is remarkably effective, the increase in polyhydric alcohols did not exceed about 0·1 per cent (wet weight) in many species; at the same time, increase in sugars ranged from about 1·0 to 1·6 per cent (wet weight) in all species. Moreover, any positive correlation between the amount of polyhydric alcohols and the hardiness of trees was not observed in 17 species examined (Table 1).

From the results mentioned above, it is obvious that in both natural and artificial frost hardening polyhydric alcohols play little part in the increase of the frost hardiness in most woody plants. However, in the species in which the total content of polyhydric alcohols amounts to about 40 per cent of the total sugar content, namely, in the *Gardenia*, apple tree, mountain ash and pomegranate, polyhydric alcohols

Table 1. Content of Various Polyhydric Alcohols and Sugars in Twig Bark or Leaf of Woody Plants in Winter

Species	Mannitol	Sorbitol	Glycerol	Total polyhydric alcohol (P)	Total sugar (S)	$\frac{P}{S} \times 100$	Frost hardiness (freezing for 24 hr.)	Material used
Betula tauschii Kolda.	0·23	0·05	0·07	0·35	5·23	6·74	−30° C.*	twig bark
Salix koriyanagi Kimura	0·20	0·06	0·08	0·34	5·40	6·34	−30° C.*	twig bark
Populus nigra L. var. *italica* Muenchh.	0·14	0·05	0·02	0·21	4·69	4·44	−30° C.*	twig bark
Larix leptolepis Murray	0·40	0·09	0·03	0·51	5·29	9·70	−30° C.*	twig bark
Taxus cuspidata Sieb. et Zucc.	0·16	0·10	0·06	0·31	4·27	7·15	−30° C.*	leaf
Pinus pentaphylla Mayr.	0·13	0·03	0·06	0·22	3·97	5·60	−28° C.	leaf
Rosa rendaina L.	0·35	0·06	0·04	0·45	5·26	8·55	−28° C.	twig bark
Rhododendron farrae Franch. var. *caesia* Nakai	0·18	0·10	0·05	0·22	4·65	4·77	−28° C.	leaf
Abies mauriana Miyabe et Kudo	0·11	0·04	0·08	0·24	4·00	5·89	−25° C.	leaf
Morus bombycis Koidz.	0·07	0·03	0·04	0·15	4·29	3·43	−25° C.	twig bark
Malus pumila Mill.	0·47	1·15	0·03	1·64	3·15	52·10	−25° C.	twig bark
Platanus orientalis L.	0·33	0·08	0·13	0·54	4·77	8·88	−25° C.	twig bark
Euonymus radicans Sieb.	0·14	0·20	0·15	0·45	3·82	11·85	−25° C.	leaf
Punica granatum L.	0·50	0·01	0·05	1·49	3·56	41·80	−15° C.	twig bark
Laurus nobilis L.	0·25	0·45	0·03	0·73	3·61	20·22	−15° C.	leaf
Thea sinensis L.	0·08	0·05	0·12	0·13	3·33	4·00	−15° C.	leaf
Gardenia jasminoides Ellis	0·80	0·59	0·02	1·36	2·54	55·00	−12° C.	leaf
Picea glehnii Mast.	0·07	0·06	0·04	0·16	2·89	5·66	—	leaf
Sorbus commixta Hedlund.	0·35	1·05	0·02	1·42	3·48	40·90	—	twig bark

Quantity of polyhydric alcohols and sugars are expressed in percentage fresh weight. Degree of frost hardiness is represented by the minimum temperature at which the twig or leaves are able to survive freezing for 24 hr. *(At least.) All samples were taken in January exclusive of *Sorbus commixta* and *Picea glehnii*, which were taken on March 1.

are considered to play some part in the increase of their frost hardiness.

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Growth of Lake Victoria Phytoplankton in Enriched Cultures

IT has been stated that many of the natural waters of Africa are short of sulphates[1], and as a broad generalization this is not to be denied. However, it has also been suggested that sulphates, as well as nitrates and phosphates, are a limiting factor for plankton growth in Lake Victoria[2], and that shortage of sulphates in solution is a factor affecting the productivity of the Lake[3]. During a recent six-months stay at the East African Fisheries Research Organization Laboratory in Jinja, Uganda, a small part of my time was devoted to culture experiments, and some successful attempts were made to grow Lake Victoria phytoplankton in laboratory culture.

The phytoplankton most usually dominant in Lake Victoria is *Melosira nyassensis* var. *victoriae*, though other diatoms, including *M. granulata*, *M. italica*, *M. agassizii* and *Nitzschia acicularis*, and blue-green algae, including *Aphanocapsa elachista*, *Merismopaedia elegans* and *Lyngbya circumcreta*, are often present. *Melosira* is the most important genus and forms the major source of food, in the Lake itself, for the herbivorous fish, *Tilapia esculenta* and *T. variabilis*, and most attention was paid to *Melosira* in this investigation.

To each of thirteen clean, sterilized, plugged 250-ml. conical flasks was added a 125-ml. aliquot from a fresh, well-mixed, water sample from the Lake. One of these was treated as a control, and to each of the others was added sterile nutrient solution as follows: to cultures S_1, S_2 and S_3, 10 ml. of magnesium sulphate solutions of such concentrations as to produce culture concentrations of, respectively, 1·3, 13 and 130 mgm./l. of sulphate; to cultures P_1, P_2 and P_3, 10 ml. of dipotassium hydrogen phosphate solutions to produce, respectively, 0·874, 8·74 and 87·4 mgm./l. of phosphate; to cultures N_1, N_2 and N_3, 10 ml. of potassium nitrate solutions to produce, respectively, 1·07, 10·7 and 107 mgm./l. of nitrate. To each of a fourth series of three cultures, SPN_1, SPN_2 and SPN_3, was added a mixture of the three nutrient substances at the concentration-levels as described. In calculating these concentrations it was assumed that sulphate, nitrate and phosphate were nil in the Lake water.

Counts of algae were made, by the sedimentation method[4-6] in the original Lake sample, and for each of the thirteen cultures at intervals of six or seven days for the next three weeks. A final count was made for some of the cultures after a further four weeks.

The response of *Melosira* (mainly *M. nyassensis* var. *victoriae*) to some of these different cultures is shown in Fig. 1. No growth occurred in S_1 and S_2, and the difference between S_3 and the initial inoculation density is insignificant. It can be stated, therefore, that added sulphate had no effect on the growth of *Melosira*. Nitrate at 1·07 and 107 mgm./l. had no effect on the growth of *Melosira*, and the cultures N_1 and N_2 are not recorded in Fig. 1. Nitrate at 10·7 mgm./l. (culture N_2) apparently boosted growth initially but after a further six days many dead cells were found in the N_2 culture. On the other hand, the addition of phosphate, particularly in the most dilute form, resulted in a significant increase in *Melosira*. After a further four weeks there were more than 3,000 cells per ml. in culture P_1. *Melosira* also showed a significant increase in culture SPN_3, where all three nutrients were added at the most concentrated level. No growth occurred in SPN_1 or SPN_2; but the reason for this is unknown.

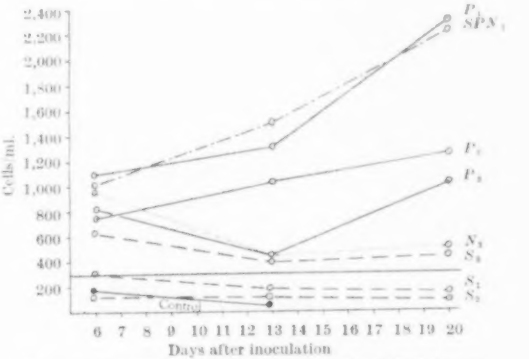

Fig. 1. Effects of added nutrients on growth of *Melosira* spp. in mixed cultures. Horizontal line, original inoculation density

None of the three species of blue-green algae investigated showed a significant increase on the addition of phosphate, nitrate or sulphate; but factors other than nutrient limitations might have been responsible for this.

The Chlorococcales present in the original inoculum, especially *Ankistrodesmus falcatus*, showed an increase in all the cultures with additional nutrients, least so for phosphate and most for nitrate at 107 mgm./l. For these forms, then, the level of sulphate concentration in Lake Victoria might be, with nitrate and phosphate, a limiting factor, and this agrees with the results of culture experiments in which test algae were used[2].

The most important genus, *Melosira*, in the Lake Victoria phytoplankton, however, is apparently not limited by the level of sulphate but is sensitive to phosphate, and hence the biological productivity of Lake Victoria, at the present time, is probably more dependent on phosphate than on sulphate.

I should like to express my gratitude to the Colonial Office for the award of a six-months research fellowship during the tenure of which this work was carried out.

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A Simple Medium for the Demonstration of Chlamydospores of *Candida albicans*

While investigating the formation of chlamydospores by different species of the fungus *Candida*, it was observed that human serum as a medium gave good results. Cultures of *Candida albicans* 10, *Candida tropicales* 10, *Candida krussei* 10, and *Candida stellatoidea* 10, *Candida guillarmondi* 1, and *Candida pseudotropicales* 1, were examined by the following technique: 24-hr. growth in Sabouraud's dextrose agar medium was emulsified with 1 c.c. of sterile normal saline; then 1 c.c. of this emulsion was added to a test-tube containing 4 drops of normal human serum, and the tube was incubated at 37° C. in a water-bath. After a lapse of 24, 48 and 72 hr., cover-slip preparations were examined under the microscope. In each instance, where cultural and biochemical tests for a strain conformed to those for *Candida albicans*, chlamydospores were produced after a lapse of 24 hr. Chlamydospores, however, did not develop with other types. Thus the above findings show that this method is very simple, less expensive and less time-consuming than routine methods.

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Growth of a Nematode in Tomato Plants grown on Sodium-deficient Water Cultures

Host plants deficient in nitrogen, phosphorus, potassium, magnesium, sulphur and iron will support a population of the root-knot nematode *Meloidogyne javanica*[1], whereas plants on full nutrient and heavily infected with *M. incognita acrita* do not show deficiencies of these elements[2]. It has been reported[3], however, that tomatoes infected with *M. incognita acrita* show less sodium in their tissues than do uninfected plants.

It may be that members of the genus *Meloidogyne* require large amounts of sodium during their development, and the following experiment was undertaken to test the effect of 'sodium deficiency' on the growth and reproduction of *M. javanica* grown in tomatoes. The terms 'sodium deficient' and 'sodium free' used here refer to plants grown in water cultures in which the presence of sodium has been reduced to a minimum.

All seeds used came from a single susceptible tomato plant of the variety Pan America. They were washed six times in water distilled from a silica still which was changed hourly. This water, which was used throughout the experiment, contained 0·0002 p.p.m. sodium.

Nutrient salts were re-crystallized as many as six times, and their sodium content estimated before use. The seeds were germinated on nylon mesh over distilled water. When the radicles were about 1 cm. in length, a culture solution of half concentration containing 0·0042 p.p.m. sodium was substituted for the distilled water. The concentrations of salts used and the methods of growth in polythene containers have been described[4].

Sodium was estimated, using a 'Si-Ro-Spec' atomic absorption instrument[5], on a dry-weight basis. The methods used in infecting the plants and in measuring the growth of the nematodes have been described[1], except that the agar was dialysed against distilled water as a 5 per cent gel for five days with six changes before it was used. A 0·5 per cent solution of the dialysed agar was used as the infecting medium.

Infective larvæ of *M. javanica* were washed several times over a sintered glass filter of pore diameter 5–15μ before being placed in the agar. The plants were exposed to infection for a period of 48 hr. and were then removed. The roots were washed in distilled water before being returned to the nutrients.

The plants were grown in a cooled glass-house from which dust contamination was reduced by a positive pressure of filtered air. A diurnal temperature variation between 60° and 110° F. was maintained during the experiment.

Plants grown in the presence of sodium were grown in culture solutions identical with those without sodium except that they had 0·1 m.equiv./litre of sodium sulphate added. The roots and leaves of these plants were hydrolysed separately in silica Kjeldahl tubes using a mixture consisting of 5 ml. concentrated nitric acid, 1 ml. concentrated sulphuric acid and 1 ml. concentrated perchloric acid, all these chemicals being A.R. grade. Blanks consisting of these chemicals were included in all hydrolyses and sodium estimations.

Throughout the experiment the growth of plants in all treatments was similar. Plants were harvested at 7, 14, 21 and 28 days, and their dry weights were similar, whether or not they were infected or whether or not they had sodium. At the final harvest, average weights of twelve plants from each of the two treatments were approximately the same (6·4 gm.).

The amounts of sodium in the roots and leaves of these plants showed marked differences. Tomato plants grown on a 'sodium free' culture solution showed uniform amounts of sodium which ranged from 20 to 50 p.p.m. throughout the entire experiment for both roots and leaves; the roots always contained sodium in a slightly higher concentration than the leaves.

Plants grown with sodium showed a steady increase in uptake of this element in the roots throughout the entire experiment, ranging from 120 p.p.m. at the first (seventh day) harvest to 1,410 p.p.m. at the final (twenty-eighth day) harvest. The leaves of these plants, however, did not show an increase in sodium concentration throughout the experiment.

These results suggest that sodium accumulates in the roots of tomato plants when the amounts mentioned above of sodium are supplied. Infection was not consistent using agar, and although great care was taken to make this procedure as uniform as possible, in several instances plants remained uninfected.

Infected 'sodium-free' plants were harvested at 7, 14 and 28 days, and galled roots were cut away from the plant and fixed in buffered 1 per cent osmium tetroxide at *p*H 7·2. They were washed in several changes of distilled water and at each harvest fifty nematodes were dissected at random and their cross-sectional area measured as previously described[1].

Growth of these nematodes on tomatoes containing 20–50 p.p.m. sodium was quite normal. They moulted, produced egg sacs, eggs and viable larvæ which were capable of re-infecting tomato seedlings,

and it appears that the amount of sodium removed from 'sodium-deficient' tomato plants by light infections (several hundred per plant) of these parasites is negligible, as at the final harvest infected 'sodium-free' plants gave a reading of 40 p.p.m. sodium compared with 35 p.p.m. sodium for uninfected 'sodium-free' plants. From these observations it is clear that *Meloidogyne javanica* does not require a large amount of sodium during its development.

P. P. Thomson assisted in all phases of this work and his help is gratefully acknowledged.

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Mechanism of Trail-laying in Two Species of Termites

During recent investigations on the behaviour of the primitive termite *Zootermopsis nevadensis* (Hagen), evidence for trail-laying was obtained when it was noted that nymphs accurately followed the path taken by one nymph over a clear unobstructed surface in an artificial nest, even when the direction of the light and the position of the nest were altered. This, to my knowledge, is the first mention of trail-laying in a lower termite.

Subsequent experiments using squashes and petroleum ether extracts of various parts of the body and organs of individuals of *Z. nevadensis* and *Nasutitermes cornigera* Motschulsky have shown that in these two genera, belonging to two widely separated families (Hodotermitidae and Termitidae), trails are produced by a substance secreted by a gland in the ventral part of the fifth segment of the abdomen. Grassé and Noirot[1], however, from work on *Macrotermes bellicosus* (Smeathman), *Macrotermes natalensis* (Haviland) and *Odontotermes magdalenae* (Grassé and Noirot) believe that in these species trails are marked by faecal droppings or pellets of earth. In *Z. nevadensis* and *N. cornigera* no trails made with squashes or petroleum ether extracts of the gut, contents of alimentary canal or rectum and drawn on a white card were followed, whereas similar trails drawn with extracts and squashes of the gland produced clear-cut trail-following. *Nasutitermes* does appear to follow a visible trail of faecal droppings, however, but this is thought to be a consequent phenomenon and not the initial trail marker. When a scarcely visible, by-pass trail, made from the cleaned integument containing the gland, was drawn in competition with a natural trail that had reached the stage where it was quite visibly marked by faecal droppings, both the workers and soldiers of *Nasutitermes* followed the by-pass in preference to the old trail.

The secretion from the gland has been shown to act as a trail releaser as well as marking the trail.

The trail-laying gland in *Zootermopsis* and *Nasutitermes* appears homologous to that described very briefly in *Kalotermes flavicollis* (Fabr.) by Grassi and Sandias[2], and by Montalenti[3], and in *Rhinotermes nasutus* (Perty) by Holmgren[4]. Grassé[5] has stated that the function of the gland in these species is unknown. In *Zootermopsis* the gland can empty through numerous small pores in the cuticle into a crude external reservoir formed by the almost complete overlapping of the fifth sternite by the preceding one. The nymphs of *Zootermopsis* are often seen dragging their abdomens along the ground when moving, thus bringing segment 5 in contact with the substrate, while the segments at the extremity of the abdomen are clear of the ground. The substance from the gland can thus quite easily escape from the reservoir on to the surface on which the insect is crawling.

All the observations and experiments on *Zootermopsis* were made on laboratory colonies which had been conditioned to live in constant illumination provided by a 'Daylight' fluorescent lamp.

A full account of this work and a description of the gland in *Zootermopsis* and *Nasutitermes* will be published elsewhere.

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CYTOLOGY

Auto-Alloploid Nature of *Pennisetum squamulatum* Fresen

Cytological observations carried out in this laboratory on *Pennisetum squamulatum*, an East African[1] grass species, and on its F_1 hybrid[2] with pearl millet (*Pennisetum typhoides* Stapf and Hubb.), have suggested that *P. squamulatum* is an auto-allopolyploid.

Raman, Chandrasekharan and Krishnaswamy[2] reported that the species possessed $2n = 54$ chromosomes and that, during meiosis in the pollen-mother-cells, bivalents and quadrivalents (1 per cell) were formed. We re-examined meiosis in the pollen-mother cells of this species and observed the types of chromosome association which suggested the polyploid nature of this species (Table 1).

Table 1

	Quadrivalents	Trivalents	Bivalents	Univalents
Average frequency per cell	3·14	1·06	17·90	1·91
Range	1–8	0–2	11–23	0–4

Total cells observed: 36

During 1958 the cross, *P. typhoides* × *P. squamulatum*, was attempted on an extensive scale. For this, pollen from a single plant of *P. squamulatum* was dusted on a large number of ears of *P. typhoides* without emasculation. In 1959, 11 plants were raised in the field from the seed set on the male parent and about 600 plants from the seed set on the ears of *P. typhoides* used for crossing. Seven out of these 11 plants of *P. squamulatum* were examined cytologically, and all of them were found to possess

$2n = 54$ chromosomes, thus suggesting that, despite multivalent and univalent formation, the species was fairly balanced in respect of chromosome number. Of the plants raised from the seed set on the crossed ears, all but one were matromorphic. The single hybrid plant possessed $2n = 41$ chromosomes. During meiosis in the pollen-mother-cells of the hybrid 32 out of 36 clearly analysable cells showed 16 bivalents and 9 univalents; the remaining four cells showed 14–15 bivalents and 11–13 univalents per cell.

From the number of chromosomes and from the most frequent mode of chromosome association observed in the hybrid during meiosis it would appear that the hybrid plant arose from the union of an unreduced 14-chromosome *typhoides*-gamete with a normal 27-chromosome *squamulatum*-gamete. It would also appear that, of the 16 bivalents observed in the hybrid, 7 were derived from the *typhoides*-parent and 9 from autosyndetic pairing in the 18 out of the 27-chromosome complement derived from the *squamulatum*-parent. These observations further suggest that *P. squamulatum* ($2n = 54$) is an auto-allopolyploid[4] comprising in its somatic complement a 9-chromosome genome represented in the auto-tetraploid condition and another 9-chromosome genome in the diploid condition. Supporting evidence for such a view is obtained from the study of meiotic chromosome behaviour in *P. squamulatum*, where as many as 8 quadrivalents, out of the possible 9, were noticed in two cells.

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A Simplified Method for the Study of Chromosomes in Man

Bottura and Ferrari[1] have described recently a rapid technique for the cytological preparation of human chromosomes, which involves intravenous injections of deacetylmethylcolchicine 2 hr. prior to a sternal marrow puncture. The marrow is then treated with hypotonic citrate, hydrolysed and stained. As they rightly point out, there are some advantages in this rapid technique over the short- or long-term tissue culture.

We have been employing similar techniques and have obtained good preparations of human chromosomes from dividing cells in the sternal marrow by giving the patient 1 mgm. of colchicine intravenously 1 hr. before the puncture. The material is then placed in 0·72 per cent w/v sodium citrate for 10 min., fixed in 3 : 1 (ethanol acetic), hydrolysed for 6 min. in *N* hydrochloric acid and stained in orcein (Fig. 1). Satisfactory preparations have also been made without giving the colchicine, relying only on the action of the hypotonic citrate; although, as would be expected, the contraction of the chromosomes is not then so well developed.

These simple procedures are extremely useful for the rapid screening of human material. They would

Fig. 1

suffer perhaps from the disadvantage that they may not detect a chimærical situation. Their outstanding advantage, however, is the establishment of the *in vivo* situation in conditions such as leukæmia, where the results of culture techniques may not be truly representative.

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Use of Induced Rooting in Cytological Studies

The common practice for the study of somatic chromosomes is to cut sections or squash the growing root-tips of a seedling. Occasionally successful preparations of somatic chromosomes have also been made from very young leaves and buds, but still in most cases root-tips continue to be favourite material for the study of somatic chromosomes. Seeds of wild plants, however, unlike those of the cultivated ones, are not always easily available, and this accounts at least in part for the fact that chromosome number in members of the former group have either not been determined or, if determined at all, reported from meiotic studies. This is evident from a cursory examination of the "Chromosome Atlas of Flowering Plants"[1]. The present work was started to find if these difficulties could be overcome by inducing adventitious root formation in isolated shoots and leaves by means of treatment with various growth-promoting substances.

The procedure to induce rooting in some of the species used as given here is more or less the same as that adopted by Gregory and Samantarai[2].

Stem and leaf of *Rauwolfia serpentina* Benth. and *Aralia filicifolia* L. have been treated with synthetic hormones, indole-3-acetic acid and naphthyl acetic acid. Several concentrations of these hormones were tried for treatment. In each concentration used, either stem cutting or the petiole of a leaf was placed for 24 hr. Then after thorough washing in running tap-water for ½ hr., the cutting or the leaves were transferred to specimen tubes containing tap-water which in turn were placed in a humid glass chamber. The materials were washed every 24 hr. in running tap-water and put back in the moist chamber. Indole-3-acetic acid of any concentrations could not induce rooting in *Aralia filicifolia* L., but some roots came out from the stem cutting of *Rauwolfia serpentina* Benth. after 25–30 days from the date of the treatment in 50 p.p.m. On the other hand, stem cuttings and a solitary leaf of the above two species, when treated with naphthyl acetic acid (10 p.p.m. for the solitary leaf and 50 p.p.m. for the stem), induced rooting after only 10 or 12 days. Thus it seems that naphthyl acetic acid is more effective for inducing rooting in these plants than indole-3-acetic acid, which is also evident from the fact that naphthyl acetic acid-treated materials developed copious and healthy roots, instead of solitary roots obtained from indole-3-acetic acid-treated materials. The stem and the leaf for such treatment should not be very old.

Squash preparations of the root-tips of the above species have been made after pre-treatment with 0·002 *M* 8-hydro-oxyquinoline for 3–4 hr. at about 18° C. The root tips were squashed either in 1 per cent propionic orcein or in acetic orcein. Before squashing, the root-tips were stained in a solution of 2 per cent acetic or propionic orcein and *N* hydrochloric acid in a ratio of 9 : 1 for 5 min. at 60° C. This staining procedure of keeping the root-tips for 5 min. at 60° C. in 9 : 1 acetic or propionic orcein and *N* hydrochloric acid has been found to give much better results, that is, uniform staining, than that given by Sharma and Mookerjee[3] in which the root tips are warmed on a burner. It is possibly due to non-uniformity of heating on a burner that the materials sometimes appear as under- or over-stained.

The chromosome counts of the species noted above show $2n = 24$ in *Aralia filicifolia* L., which is the same number as reported by Wanscher[4] and $2n = 20$ in *Rauwolfia serpentina* Benth. Since the somatic chromosome number of *Aralia filicifolia* L., determined here from induced roots, is the same as that reported by Wanscher from normal roots, it appears that growth-promoting substances do not in any way disturb the chromosome number and morphology.

My sincere thanks are due to Prof. R. P. Roy and Dr. J. P. Sinha, Botany Department, Patna University, for their encouragement and help.

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GENETICS

New Recurrent Series in Inbreeding Phenomena

A NUMBER of recurrent series have been found in phenomena related to inbreeding. A new series is represented by the sequence of the values of f'_m (the mean coefficient of inbreeding for sex-linked genes[1] in a strictly panmictic population model, as defined by Freire-Maia and Freire-Maia[2]), from sib matings through the subsequent simple full degrees of consanguinity (uncle–niece plus aunt–nephew, $UN + AN$; first cousin, $1C$; first cousin once removed, $1\frac{1}{2}C$; second cousin, $2C$; etc.). This series is as follows: 1/4, 3/16, 5/64, 11/256, 21/1,024, 43/4,096, 85/16,384, . . . (Fig. 1) (cf. Freire-Maia and Freire-Maia[2] and unpublished work, and Freire-Maia and Marçallo[3] for these terms). Knowing two consecutive values, the following value may be calculated by the formula:

$$x'_n = \frac{1}{4}\left(x'_{n-1} + \frac{1}{2}x'_{n-2}\right)$$

The general solution for this equation is:

$$x'_n = \frac{1}{3}\left(\frac{1}{2}\right)^n - \frac{1}{12}\left(-\frac{1}{4}\right)^n \qquad (1)$$

Excluding x_0, which corresponds to sib mating, and x_1, corresponding to $UN + AN$, all the other consanguineous matings (that is, the cousin matings) have their positions in the series given by multiplying their respective abbreviated representation (1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$ . . .) by 2. Third cousins once removed ($3\frac{1}{2}C$) are, for example, the seventh term.

The sequence of the values of f (Wright's coefficient of inbreeding for autosomal genes) for the offspring of the same above-mentioned consanguineous unions also forms a recurrent series (1/4, 1/8, 1/16, 1/32, 1/64 . . .) which is also a geometric progression (Fig. 1). Any one of its terms may be calculated according to the formula:

$$x_n = \frac{1}{4}\left(\frac{1}{2}\right)^n \qquad (2)$$

In these two recurrent series, the limiting value of x'_n and x_n as $n \to \infty$ is 0. This limit is approached in an oscillatory way by x'_n in the first series (cf. formula 1).

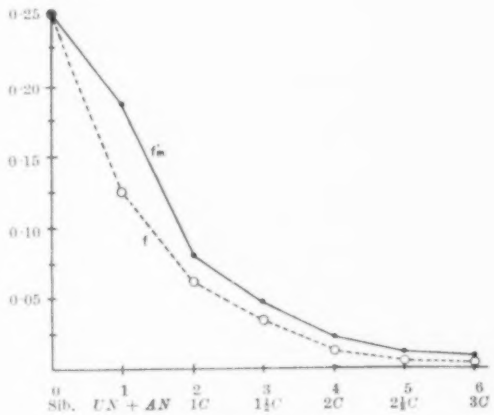

Fig. 1. The first values of f and f'_m

The ratio of formula (1) to formula (2) is:

$$x'_n = \frac{4}{3} - \left[\frac{1}{3}(-1)^n\right]\left(\frac{1}{2}\right)^n$$

which is the general formula for any term of a new recurrent series. The limiting value (4/3) is rapidly approached in an oscillatory way (Fig. 2) similar to that found by Jennings[4] for the equilibrium of sex-linked genes in random mating populations. In cases of distant consanguinity, f'_n may be accepted as being roughly equal to 1·33 f. The terms of this oscillating series are: 1, 3/2, 5/4, 11/8, 21/16, 43/32, 85/64, 171/128, 341/256, . . . Knowing two consecutive terms:

$$x_n = \frac{1}{2}(x_{n-1} + x_{n-2})$$

The above-mentioned oscillatory approach is due to the fact that the first series is composed of alternating terms of two other series—one for the consanguinity between persons belonging to the same generation (sibs and cousins of the nth degree) and the other for the consanguinity of persons belonging to different generations ($UN - AN$ and cousins of the nth degree once removed) (Fig. 2).

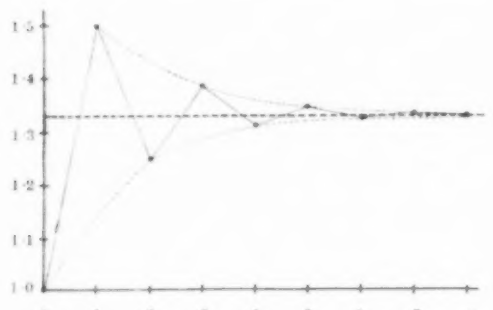

Fig. 2. Oscillatory approach of the ratio f'_n/f to the limiting value 4/3 as $n \to \infty$

Each term of the series for persons belonging to the same generation may be found as follows:

$$x_n = \frac{5}{16}x_{n-1} - \frac{1}{64}x_{n-2}$$

yielding the general solution:

$$x_n = \frac{1}{3}\left(\frac{1}{4}\right)^n - \frac{1}{12}\left(\frac{1}{16}\right)^n$$

for initial values $x_0 = 1/4$ and $x_1 = 5/64$.

Each term of the series for persons belonging to different generations may be calculated as follows:

$$x_n = \frac{5}{16}x_{n-1} - \frac{1}{64}x_{n-2}$$

yielding the general solution:

$$x_n = \frac{1}{6}\left(\frac{1}{4}\right)^n - \frac{1}{48}\left(\frac{1}{16}\right)^n$$

for initial values $x_0 = 3/16$ and $x_1 = 11/256$.

This investigation was supported by grants from CAPES, the Rockefeller Foundation, the National Research Council of Brazil, and the Research Council of the University of Paraná.

We are indebted to Dr. David Carneiro, jun., for his valuable suggestions.

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Genetic Recombination in Bacteriophage ΦX 174

Recently, Tessman[1,2] and Sinsheimer[3] suggested that the deoxyribonucleic acid of ΦX 174 is one-stranded in contrast to the double-stranded deoxyribonucleic acid of other phages. From this point of view it seemed interesting to investigate genetic recombination in this phage. Tessman[4] achieved recombination in bacteriophage *S* 13 by stimulation with ultra-violet irradiation of free virus particles. (*S* 13 is serologically related to ΦX 174 and similar in other properties.) The frequency of recombinants found after ultra-violet irradiation was of the order of 0·1 per cent. In other work[5] without irradiation, no recombination could be detected.

A selective system for host-range recombinants, similar to the negative host-range system in *T2* (ref. 6), could be developed in ΦX 174: *E. coli C* were plated on colour-agar plates (Bresch and Trautner[7]) with an excess of ΦX 174 and a resistant strain C_a was isolated. A host-range mutant of ΦX 174 against C_a was then selected and called *Ha*. By repeating these procedures a second-step bacterial mutant C_{ab} and phage mutant *HaHb* were obtained. A third step resulted in a triple bacterial mutant C_{abc} and a triple phage mutant *HaHbHc*. This *HaHbHc* stock was treated with nitrite, which induces mutations by affecting the nucleic acids[8]. Negative host-range mutants (revertants) appear as turbid plaques on mixed indicator *C* plus C_{abc}.

Fifteen such revertants (numbered 1–15) were collected and crossed to each other and to the one-step (*Ha*) and two-step host-range mutant (*HaHb*). Many of these crosses resulted in recombinants, able to grow on C_{abc}. In Table 1 the recombining crosses are represented by + and the non-recombining by −. The fraction of recombinants was between 1×10^{-4} and 6×10^{-4}. The background of mutation to a C_{abc} lysing type, controlled by the 'self-crosses', was in all cases less than 10^{-7}.

From Table 1 the revertants can be placed in three groups according to whether the back mutation occurred either in *Ha*, *Hb* or *Hc*. Two exceptions (Nos. 2 and 3) seem to show reversions at two sites. A preliminary quantitative evaluation of the recombination data suggests a linear order *HaHbHc*, where the distance *Ha*–*Hb* is about half the distance *Hb*–*Hc*.

Table 1. Crosses between Revertants, either yielding Recombinants (+) or not (−)

	8	11	12	1	5	13	14	15	4	6	7	9	10	*HaHb*	*Ha*	3	2
8				−	+	+	+	+	+	+	+	+	+	+	+	+	+
11				−	+	+	+	+	+	+	+	+	+	+	+	+	+
12	−	−		−	+	+	+	+	+	+	+	+	+	+	+	+	+
1									+	+	+	+	+	+	+	+	+
5	+	+	+						+	+	+	+	+	+	−	−	−
13	+	+	+						+	+	+	+	+	+	−	−	−
14	+	+	+						+	+	+	+	+	+	−	−	−
15	+	+	+						+	+	+	+	+	+	−	−	−
4	+	+	+	+	+	+	+	+									
6	+	+	+	+	+	+	+	+	−								
7	+	+	+	+	+	+	+	+	−								
9	+	+	+	+	+	+	+	+	−								
10	+	+	+	+	+	+	+	+	−								
HaHb	+	+	+	+	+	+	+	+	−								
Ha	+	+	+						−								
3	+	+	+						−								
2				−	−	−	−	−									

The work is being continued and details will be published later.

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Australian Aborigines and Genetics

Prof. A. A. Abbie's statements[1] concerning two of my papers[2,3] on the genetics of the Australian aborigines cannot be allowed to pass unanswered. Prof. Abbie admits that he is not a geneticist, yet he throws doubt on genetical methods of racial study, even suggesting that nearly three months in Australia was insufficient time for me to obtain reliable results. He is unwilling to recognize that anatomy can only make *comparisons* between racial types, while genetical methods of family study in crosses give an *analysis* of racial differences and are thus of far greater significance. His thesis appears to be that the aboriginal population of the whole continent is a unit, and that all the evidence which shows the presence of mixed elements must be resisted or denied.

Prof. Abbie makes various comparisons of means and ranges in different local populations, for example, in stature, but he makes the long outmoded assumption that these are mere variations from a mean. He fails to see that measurements are of little value unless there is some understanding of the method of inheritance of the differences involved. Much evidence shows that stature in various races of mankind depends in part on multiple genes which are cumulative in effect, the number of such genes being probably a small one for each racial character. This applies both to stature and hair form.

Those who see the limitations of Prof. Abbie's anatomical methods should advocate the genetical approach to race studies; but unfortunately very few, at present, have the necessary combination of genetical and anthropological knowledge and experience.

As regards the Mongolian (better sacral) spot, one would be surprised to find it in the aborigines in view of all their other racial characters, which are mainly archaic Caucasoid except the darker skin colour.

Regarding the dwarf element in certain tribes of Queensland, Prof. Abbie does not mention that my conclusions are a confirmation of those of Tindale and Birdsell[4] that these people are a remnant of a Negritoid type which was pushed down into Tasmania (with a limited amount of crossing with Australian aborigines) when the latter entered Australia from the north and moved south. There are few cases of early racial migration for which the evidence to unprejudiced minds is so unequivocal. Yet Prof. Abbie not only denies it but says that this is "a fair example of ignoring facts to push a hypothesis". He achieves this by referring to the fact, stated by Tindale and Birdsell[4] as well as myself[2], that some of the Queensland dwarfs have a yellowish skin colour. He is evidently unaware of the elementary fact that this is simply due to dilute melanin. The situation is similar regarding hair form, where a few multiple genes for curly hair will account for the dispersal of this character as an occasional occurrence through the continent of Australia.

Regarding head form, Prof. Abbie ignores the extensive genetic results of my work from the study of families of mixed descent (Aborigine × White) in three generations, mainly at Alice Springs and Darwin, which breaks new ground and shows the remarkable genetic nearness of these aboriginals to the archaic Caucasoids of Europe.

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[1] Abbie, A. A., *Nature*, **187**, 375 (1960).
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I wish to make the following comments on Prof. Ruggles Gates's communication.

I freely admit to being an old-fashioned anatomist employing an archaic methodology: this, however, has the minor advantage of dealing in facts, some of them even measurable.

The close association of Australian aborigines with some basic 'Caucasoid' stock has long been widely accepted. I mentioned our failure to find a 'sacral spot' purely in passing, because some observers had previously claimed that it existed. Whether or not that had any relationship to presumed 'Caucasoid' affinities of the aborigines is beside the point.

I apologize to Prof. Ruggles Gates for any seeming discourtesy over his observation that the Queensland aborigines he examined have a yellowish skin, but I must point out that he laid himself open to adverse comment. He cites "a tendency toward yellowish brown skin colour" as characteristic of "Barrineans". I said that Prof. Ruggles Gates knew that in all aborigines the skin fades to a yellowish colour when protected from direct sunlight; this, of course, will occur in the rain forest of north-east Queensland. I am quite well aware that the yellowish colour is probably due to dilute melanin, as I had indicated in an earlier paragraph. But if any aborigine can fade to a yellowish colour, such colouring cannot be considered ethnically distinctive within Australia.

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SOIL SCIENCE

Microbiological Changes in Freshly Moistened Soil

It is well known that when a dried soil is moistened there is a burst of respiratory activity. Drying, in some way, renders a part of the soil organic matter soluble and it has been considered that the decomposition of this fraction by micro-organisms partly accounts for the high respiration-rates recorded. The composition of this soluble material has not been fully determined, but it has been shown to contain appreciable amounts of several amino-acids[1]. In these circumstances the development of a specialized zymogenous population might be expected. Indirect evidence for the existence of such a population has been provided by Chase and Gray[2]. They made a detailed analysis of the respiration of freshly moistened soils and concluded that their results could be best interpreted by assuming that two major microbial populations were involved, namely, one with a low rate of metabolism—the autochthonous population—and the other with a very high rate—the zymogenous population.

Observations made recently on the behaviour of the bacteria in an East African soil (Kikuyu red loam) provides direct evidence for this interpretation. Soil which had been dried was re-moistened to field capacity and maintained at 25° C. Rate of carbon dioxide production and bacterial numbers were recorded at 3-hourly intervals for a period of 36 hr. Carbon dioxide was determined in the macro-respirometer devised by Birch and Friend[3] and bacterial numbers by direct cell counting[4]. Note was taken of the morphology of all cells scored and it was found that the two main cell types (cocci and rods) showed marked differences in their distribution over the 36-hr. period. From Fig. 1 it can be seen that a comparatively small increase in coccoid forms occurred early, their numbers then remaining at a fairly steady value. Rods, on the other hand, showed no increase until after 12 hr., when their numbers increased rapidly to a maximum at 24 hr.

It will be recalled that Winogradsky[5] considered the autochthonous flora of the soil to be composed almost exclusively of cocci and very short rods, whereas the zymogenous flora comprised sporeformers and long rods. The present results can be interpreted as showing that the rods constitute the zymogenous part of the population and, in fact, are responsible for the greater part of the flush of carbon dioxide. Although numerically they do not at any time constitute more than 50 per cent of the total population, their size in comparison with the cocci is such that they must, during their brief period of growth, constitute the greater part of the active cellular material in the soil. Moreover, it is well established that maximum physiological activity occurs during the lag and early log phase in the growth of a bacterial culture and it is clear that in the present instance maximum carbon dioxide production coincides with this part of the growth curve of rods rather than with the point of maximum number.

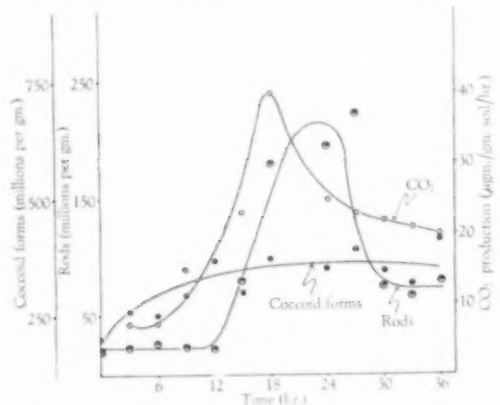

Fig. 1. Carbon dioxide production (○) and development of bacterial populations in moistened soil. ●, Coccoid forms; ◓, rods

This work, which is being continued and will be reported more fully elsewhere, was undertaken when one of us (E. G.) was in receipt of a travelling grant from the Colonial Office.

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MISCELLANY

Letter from Erasmus Darwin to Jonas Dryander

The following extract from a letter of Erasmus Darwin to Jonas Dryander seems worth noting. The letter is in a small collection in the Department of Botany, British Museum (Natural History) labelled "Dryander Correspondence".

"Derby, May 21–87

. . . I must now beg another favor of you, which is to give your suffrage to my Son, Dr. Robt. W. Darwin, whom I wish to be a member of the Royal Society, which might add new spirit to his industry in philosophical pursuits; & should be much obliged to you to present my best compl. to Dr. Blagden, when you see him, & ask for my Son the same favor from him. Mr. Ch. Greville has spoken to Sr. Joseph Banks in his favor, whom I should otherwise have troubled with a letter on this account. Doctor Robt. Darwin is settled in Shrewsbury, where he meets with very great encouragement, having been concern'd for near fifty patients in the first six months; & I dare say will make a very useful member of the Society."

Robert Darwin "began to practise before he was twenty-one years old" (Charles Darwin, *The Autobiography*).

John Ramsbottom

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Surrey.

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 6

UNIVERSITY OF LONDON (in the Assembly Hall, Institute of Education, Malet Street, London, W.C.1), at 5.15 p.m.—Mr. R. W. Young: "The University and the Grammar School".*

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the London Planetarium, Marylebone Road, London, N.W.1), at 5.30 p.m.—Mr. Leonard Clarke: "Greek Astronomy and Its Debt to the Babylonians".

SOCIETY OF ENGINEERS (at the Geological Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Mr. W. E. Humphrey: Presidential Address.

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. James Taylor: "The Modern Chemical Industry in Great Britain". (Last of three Cantor Lectures.)

SOCIETY OF CHEMICAL INDUSTRY, LONDON SECTION (joint meeting with the LONDON SECTION of the ROYAL INSTITUTE OF CHEMISTRY, at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. H. H. Chambers: "Fuel Cells".

SOCIETY OF INSTRUMENT TECHNOLOGY, DATA PROCESSING SECTION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Prof. J. E. Parton and Mr. A. Rose: "The Universal Decision Element".

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. J. Ward-Perkins: "Etruria's Past".

Tuesday, February 7

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at 14 Belgrave Square, London, S.W.1), at 10.30 a.m.—Meeting on "Alternative Nitrogen Fertilizers".

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. W. G. Chaloner: "Wandering Continents and Fixed Ideas—a Discussion of the Evidence for Continental Movement".*

BRITISH INSTITUTION OF RADIO ENGINEERS (joint meeting with the ELECTRONICS GROUP of the INSTITUTE OF PHYSICS, at the Institute of Physics, 47 Belgrave Square, London, S.W.1), at 2.15 p.m.—Meeting on "Tunnel Diodes".

BRITISH SCHOOL OF ATHENS (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. Sinclair Hood: "Excavations at Knossos (Crete), 1960".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENT AND ELECTRONICS SECTIONS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. E. M. Bradley: "Magnetic Properties of Thin Films for Computing Devices".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. R. Knox: "Contrasting Patterns of Drug-Resistance in Tubercle Bacilli and Staphylococci".* (Eighth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.)

ROYAL INSTITUTE OF CHEMISTRY (joint meeting with the Sir John Cass College Chemical Society, at the Sir John Cass College, Jewry Street, London, E.C.3), at 6.30 p.m.—Prof. B. C. L. Weedon: "Organic Reactions in Strong Alkalis".

Wednesday, February 8

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY, LOW TEMPERATURE GROUP (at 47 Belgrave Square, London, S.W.1), at 2.30 p.m.—Meeting on "Ultrasonic Absorption and Attenuation in Metals at Low Temperature".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. Rodney Perry: "The Timber Industry".

EUGENICS SOCIETY (at Manson House, 26 Portland Place, London, W.1), at 5 p.m.—Sir Robert Platt, Bt.: "Inherited Disease in Man" (The Galton Lecture.)

BRITISH INSTITUTION OF RADIO ENGINEERS, COMPUTER GROUP (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Mr. G. Emery: "Perseus, a Medium-scale Data Processing System".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. F. G. E. Pautard: "The Molecular Biology of Calcified Tissues".* (Second of three lectures on "The Scientific Basis of Dentistry" organized by the British Postgraduate Medical Federation.)

WOMEN'S ENGINEERING SOCIETY, LONDON BRANCH (at Hoje House, 45 Great Peter Street, Westminster, London, S.W.1), at 7 p.m.—Mr. L. J. Carter: "Space Exploration"

Thursday, February 9

UNIVERSITY OF LONDON (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 1.15 p.m.—Mr. R. A. French: "Russian Rivers in the Service of Man".*

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. J. Latham and Mr. B. J. Mason: "Electric Charge Transfer Associated with Temperature Gradients in Ice" and "Generation of Electric Charge Associated with the Formation of Soft Hail in Thunder-clouds".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. P. J. Grubb: "Alpine Plant Communities in Southern Jugoslavia".

UNIVERSITY OF LONDON (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. L. H. Collier: "Trachoma and Inclusion Blennorrhoea".* (Ninth of fifteen lectures on "The Scientific Basis of Medicine" organized by the British Postgraduate Medical Federation.

CHEMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1 at 7.30 p.m.—Meeting for the reading of Original Papers.

Thursday, February 9—Monday, February 27

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7)—Greenland—an Exhibition.

Friday, February 10

ASSOCIATION OF APPLIED BIOLOGISTS (at the British Museum (Natural History), Cromwell Road, London, S.W.7), at 10.40 a.m.—Papers on "Recent Research on Plant Virus Diseases".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Sir George Sutherland, F.R.S.: "Diamonds".

Saturday, February 11

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Mr. William Fagg: "The Art History of Benin, Nigeria".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned

ASSISTANT LECTURER (preferably skilled in or possessing a knowledge of mass spectroscopy as applied to chemical problems) IN PHYSICAL CHEMISTRY—The Registrar, The University, Leeds 2 (February 14).

IMPERIAL CHEMICAL INDUSTRIES FELLOWS FOR RESEARCH IN VARIOUS BRANCHES OF CHEMISTRY, CHEMICAL ENGINEERING, ENGINEERING, TECHNOLOGY, PHYSICS, and allied subjects—The Registrar, The University, Manchester 13 (February 14).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY, PHYSICS and allied subjects—The Registrar, The University, Manchester 13 (February 14).

SENIOR ASSISTANT OBSERVER (with a good honours degree in mathematics, physics or astronomy, and some experience of research in astrophysics)—The Director, Observatories, The University, Madingley Road, Cambridge (February 15).

TECHNICAL OFFICER (with a degree in physics or engineering and a good practical knowledge of electronics), for research into photoelectric photometry by pulse counting techniques—The Director, Observatories, The University, Madingley Road, Cambridge (February 15).

DEMONSTRATOR (with a degree in science or agricultural science) IN AGRONOMY at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, February 15).

LECTURER (physicist, preferably with an interest in observational science) IN THE DEPARTMENT OF METEOROLOGY—Professor of Meteorology, Imperial College of Science and Technology, London, S.W.7 (February 20).

ASSISTANT LECTURERS (2) IN BIOCHEMISTRY—The Registrar, Manchester College of Science and Technology, Manchester 1 (February 25).

ASSISTANT LECTURER OR LECTURER (graduate in microbiology, bacteriology, botany, biochemistry or cognate fields) in Microbiology—The Registrar (Room 22, O.R.B.), The University, Reading (February 28).

LECTURER OR ASSISTANT LECTURER IN THE DEPARTMENT OF MATHEMATICS AT MAKERERE COLLEGE (The University College of East Africa)—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (February 28).

SCIENTIFIC OFFICER (with a first- or second-class honours degree in mathematics with statistics, or a diploma in statistics) in the Statistics Section for duties mainly concerned with the design and analysis of field experiments—The Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (February 28).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY or PHYSICS—The Registrar, University College, Dublin (March 7).

LECTURER (with an honours degree in botany or agricultural botany, postgraduate research and training in plant pathology, and preferably an interest in host-parasite relations); and an ASSISTANT (with an honours degree in botany or agricultural botany, training in plant pathology, and preferably an interest in virus diseases) IN THE DEPARTMENT OF BOTANY—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (March 11).

LECTURER or ASSISTANT LECTURER IN STATISTICS—Head of the Department of Mathematics, Imperial College of Science and Technology, South Kensington, London, S.W.7 (March 24).

ASSISTANT KEEPER IN THE DEPARTMENT OF BOTANY—The Secretary, National Museum of Wales, Cardiff (April 1).

RESEARCH STUDENTS (geology graduates) IN GEOCHEMICAL PROSPECTING—Dr. Webb, Geology Department, Imperial College of Science and Technology, South Kensington, London, S.W.7 (June 1).

AGRICULTURAL CHEMIST (with a good honours degree in agricultural chemistry or chemistry with at least two years postgraduate research experience in agricultural chemistry) in Kenya, to take charge of research projects into soil and plant nutrition problems of coffee—

The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/7/050.

ANIMAL GENETICIST, to undertake research in quantitative genetics with the ultimate objective of obtaining basic information needed for an understanding of inheritance of economic traits in livestock and poultry; a FOREST BIOLOGIST (PLANT or FOREST PATHOLOGIST), to design, conduct and supervise research in diseases of forest nursery stock; and a QUANTITATIVE GENETICIST (MATHEMATICIAN or STATISTICIAN), to conduct research into methods appropriate for dealing with problems in quantitative genetics, with the Canadian Department of Agriculture—Civil Service Commission of Canada, Ottawa, Canada, quoting Ref. 61–2201.

EDITORIAL ASSISTANT (with a university degree in science or technology, and preferably at least two years postgraduate experience in science or industry)—The Manager, *Nature* Office, Macmillan and Co., Ltd., St. Martin's Street, London, W.C.2.

GRADUATE ASSISTANTS (qualified to pursue M.Sc. and Ph.D. work in chemistry)—The Chairman, Department of Chemistry, McMaster University, Hamilton, Ontario, Canada.

HEAD (with good academic qualifications in science, and preferably teaching, industrial and administrative experience) OF THE DEPARTMENT OF SCIENCE—The Principal, Cambridgeshire Technical College and School of Art, Collier Road, Cambridge.

PHYSICISTS, ENGINEERS and MATHEMATICIANS, Scientific Officer or Senior Scientific Officer grade (with a first- or second-class honours degree or equivalent in physics, electrical engineering or mathematics, and at least three years postgraduate experience for Senior Scientific Officer grade) at the Radio Research Station, D.S.I.R., Ditton Park, Slough, to investigate the upper atmosphere and the space between the Earth and the Sun, with particular reference to the propagation of radio waves through these regions, and associated problems of terrestrial and space communications—The Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.581/9A.

RESEARCH WORKER (BIOCHEMIST or CHEMICAL PHARMACOLOGIST, preferably with Ph.D. or equivalent experience), to investigate the biochemical actions of drugs currently used in the treatment of mental illness—The Director of Clinical Research, Crichton Royal, Dumfries.

SENIOR LECTURER or LECTURER (with high academic qualifications, preferably in metallurgy, coupled with practical experience of the techniques and the engineering utilization of welding) IN WELDING TECHNOLOGY—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

SENIOR TECHNICIAN FOR WORK IN THE BACTERIOLOGICAL DIVISION at Connaught Hospital, Walthamstow, London, E.17—The Secretary, Forest Group H.M.C., Langthorne Road, London, E.11.

SOIL SURVEYOR (age 26–40, with a degree in natural science or geography, with two years' postgraduate training or experience in soil survey work) in Sarawak, to carry out soil surveys—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD. 63/24/07.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

British Commonwealth Collections of Micro-Organisms. Directory of Collections and List of Species maintained in Australia. Pp. v+45. 8*s*. net. Directory of Collections and List of Species maintained in Canada. Pp. iv+48. 9*s*. net. Directory of Collections and List of Species maintained in India. Pp. iv+36. 6*s*. net. Directory of Collections and List of Species maintained in New Zealand. Pp. iv+16. 3*s*. net. Directory of Collections and List of Species maintained in the United Kingdom, Ghana and Trinidad. Pp. iv+70. 12*s*. 6*d*. net. (London: H.M. Stationery Office, 1960.) [711

Trans-Antarctic Expedition, 1955–1958. Scientific Reports. No. 2: A Gravity Traverse of Antarctica. By J. G. D. Pratt. Pp. 22. 12*s*. 6*d*. net. No. 3: Seismic Soundings Across Antarctica. By J. G. D. Pratt. Pp. 69. 30*s*. net. No. 4: Tides at Shackleton, Weddell Sea. By J. G. D. Pratt. Pp. 21+2 plates. 12*s*. 6*d*. net. (London: Trans-Antarctic Expedition Committee, 22 Gayfere Street, S.W.1, 1960.) [711

Discovery Reports, Vol. 30, pp. 301–408, plates 7–28, August, 1960: Studies on *Physalia physalis* (L.). Part 1: Natural History and Morphology. By A. K. Totton. Part 2: Behaviour and Histology. By G. O. Mackie. (Cambridge: at the University Press, 1960.) [711

Institution of Electrical Engineers. The Training of Graduates: a Report of the Joint Committee on Practical Training in the Electrical Engineering Industry. Pp. 34. (London: Institution of Electrical Engineers, 1960.) 2*s*. [811

Department of Scientific and Industrial Research: Geological Survey and Museum. The Origin and Evolution of Coal. By Dr. P. J. Adams. Pp. i+17. (London: H.M. Stationery Office, 1960.) 1*s*. 9*d*. net. [811

Tobacco Manufacturers' Standing Committee. Report for the year ended 31st May, 1960. Pp. 11. (London: Tobacco Manufacturers' Standing Committee, 1960.) [811

Endemic Goitre: World Distribution and Incidence—Select Bibliography. Second edition. Pp. iii+136. (London: Chilean Iodine Educational Bureau, 1960.) [911

Current Problems in the Understanding of Personal Responsibility: a Bibliography selected from the fields of Psychology, Sociology, Ethics and Theology. List A: Pp. 11. 1*s*. List B: Pp. 11. 2*s*. (London: Church Information Office, Church House, S.W.1, 1960.) [911

Tube Investments, Ltd. Extended Surface Tube. Pp. 28. (London: Tube Investments, Ltd., 1960.) [911

A National Fuel and Power Policy: a Policy Statement by the Association of Scientific Workers. Pp. 20. (London: Association of Scientific Workers, 15 Half Moon Street, W.1, 1960.) [1011

Department of Scientific and Industrial Research: Building Research Station. National Building Studies Research Paper No. 28: Studies in Composite Construction. Part 3: Tests on the New Government Offices, Whitehall Gardens. By R. J. Mainstone. Pp. vi+54+8 plates. (London: H.M. Stationery Office, 1960.) 8*s*. 6*d*. net. [1011

C. F. Casella and Co., Ltd. One Hundred and Fifty Years of Scientific Instrumentation, 1810–1960. Pp. 12. (London: C. F. Casella and Co., Ltd., 1960.) [1011

Report from the Select Committee on Nationalised Industries, together with the Proceedings of the Committee, Minutes of Evidence and Appendices—British Railways. Pp. cvi+505. (254–I.) (London: H.M. Stationery Office, 1960.) 22*s*. 6*d*. net. [1011

Record of the Royal Institution of Great Britain, 1960. Pp. 178. (London: Royal Institution of Great Britain, 1960.) [1111

Civic Trust: The First Three Years. Pp. 29. (London: Civic Trust, 1960.) [1111

Air Ministry: Meteorological Office. Scientific Paper No. 4: Pressure Variation over Malaya and the Resonance Theory. By R. Frost. Pp. ii+13. (M.O. 678.) (London: H.M. Stationery Office, 1960.) 2*s*. 6*d*. net. [1111

Other Countries

Canada: Department of Northern Affairs and National Resources National Museum of Canada. Bulletin No. 169: The Birds of West-Central Ellesmere Island and Adjacent Areas. By David F. Parmelee and S. D. MacDonald. Pp. iv+103 (10 plates). 1.50 dollars. Bulletin No. 170: An Archaeological Analysis of Eastern Grent Land, Ellesmere Island, Northwest Territories. By M. S. Maxwell. Pp. iv+109 (17 plates). 1.50 dollars. (Ottawa: Queen's Printer, 1960.) [711

Fiskeridirektotatets Skrifter. Serie Havundersøkelser. (Reports on Norwegian Fishery and Marine Investigations.) Vol. 12, No. 9: Another Modification of the Scholander-Roughton Technique: Nitrogen Determination in Fish Blood. By G. Sundnes. Pp. 6. (Bergen: A. S. John Griegs Boktrykkeri, 1960.) [711

Smithsonian Institution, Washington, D.C. Proceedings of the United States National Museum. No. 3436: Revision of the Milliped Genus *Cherokia* (Polydesmida: Xystodesmidæ). By Richard L. Hoffman. Pp. 227–264. No. 3437: Re-examination of Species of Protura described by H. E. Ewing. By F. Bonet and S. L. Tuxen. Pp. 265–305. No. 3438: Studies in Neotropical Mallophaga. 17: A New Family (Trochiliphagidæ) and a New Genus of the Lice of Hummingbirds. By M. A. Carriker, Jr. Pp. 307–342. No. 3439: The Pelagic Amphipod Genus *Parathemisto* (Hyperiidea: Hyperiidæ) in the North Pacific and Adjacent Arctic Ocean. By Thomas E. Bowman. Pp. 343–392. No. 3442: Descriptions on New Bats from Panama. By Charles O. Handley, Jr. Pp. 459–479. No. 3444: Noctuid Moths of the Scopulepes Group of *Hemeroplanis* Hübner. By E. L. Todd. Pp. 505–515. (Washington, D.C.: Government Printing Office, 1960.) [711

Centro de Investigacao Cientifica Algodoeira, J.E.A. Memórais e Trabalhos. No. 35: Monografia Agricola de Massinga, sede (Mocambique). Por Armando Antunes de Almeida. Pp. 104+33 fotos. No. 36: Algodao de Fibra Longa. Por J. R. Pereira. Pp. 30. No. 37: Viagem de Estudo aos Estados Unidos e ao Canada. Por Prof. A. Quintanilha. Pp. 109+51 figures. (Lisboa: Centro de Investigacao Cientifica Algodoeira, J.E.A., 1959.) [711

Twelfth Annual Report of the Pacific Marine Fisheries Commission for the year 1959. Pp. 40. (Portland, Oregon: Pacific Marine Fisheries Commission, 1960.) [711

University of California Publications in Geological Sciences. Vol. 36, No. 6: A Survey of Various Late Cenozoic Vertebrate Faunas of the Panhandle of Texas, Part 3: *Felidæ*. By Donald E. Savage. Pp. 317–344. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1960.) 75 cents. [711

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. 123, No. 2: A Review of the *Pardalis-Maculatus* Complex of the Boid Genus *Tropidophis* of the West Indies. By Albert Schwartz and Robert J. Marsh. Pp. 47–84. Vol. 123, No. 3: Eight Historic Fossil Mammal Specimens in the Museum of Comparative Zoology. By Horace E. Wood, 2nd. Pp. 85–110+1 plate. Vol. 123, No. 4: The Structure of the Choanae of the Emydinae (Testudines, Testudinidae). By Thomas S. Parsons. Pp. 111–127. Vol. 123, No. 5: The Nervous System of *Gelastocoris oculatus* (Fabricius) (Hemiptera: Heteroptera). By Margaret C. Parsons. Pp. 129–199. (Cambridge, Mass.: Museum of Comparative Zoology at Harvard College, 1960.) [711

Commonwealth of Australia: Department of Supply. Defence Standards Laboratories. Technical Note No. 55: Hardness Scales Used in Testing of Vulcanized Rubbers. By N. G. C. Neville and W. J. Wark. Pp. 11. (Maribyrnong, Victoria: Defence Standards Laboratories, 1960.) [711

Transactions of the American Philosophical Society. New Series, Vol. 50, Part 8: The Forming of the Charitable Institutions of the West of England: a Study of the Changing Pattern of Social Aspirations in Bristol and Somerset, 1480–1660. By W. K. Jordan. Pp. 99. (Philadelphia: American Philosophical Society, 1960.) 2 dollars. [711

Comité International de la Détergence: Commission Internationale de Terminologie. Classement des Agents de Surface. (Classification of Surface Agents.) Pp. 15. (Paris: Comité International de la Détergence, 70 Champs-Élysées, 1960.) 1.40 NF. [1011

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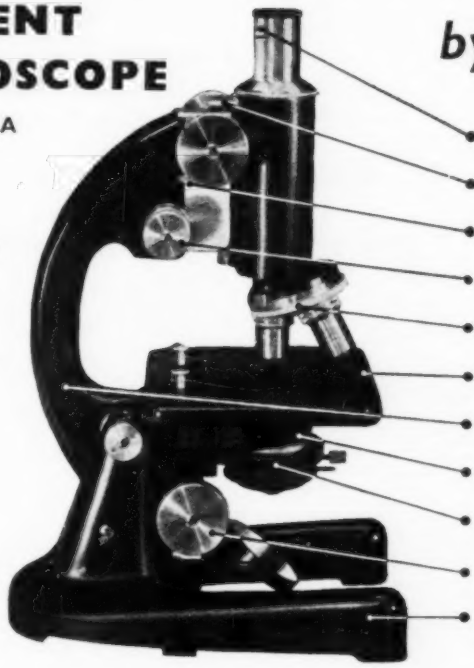

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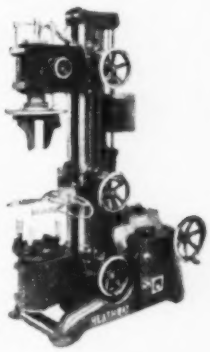

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APPOINTMENTS VACANT

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Applications to the Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks, quoting ref. 61/2.

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Forms of application may be obtained from the Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, to whom they should be returned before February 28, 1961.

THE BRITISH CERAMIC RESEARCH Association invites applications for a post in the Liaison Department of its Pottery Division. The work involves the development of new liaison activities between the Association and the industry, and requires a man with scientific or technological qualifications who has had experience in the ceramic industry.—Applications should be addressed to the Director of Research, the British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

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FUEL TECHNOLOGIST
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COMBUSTION ENGINEER

The Organization's *Division of Coal Research, Sydney, N.S.W.*, invites applications from honours graduates with an established research reputation in Science (Physics or Inorganic Chemistry, Chemical Engineering, Mechanical Engineering or Fuel Technology for a senior position as Fuel Technologist).

The appointee is required as Group Leader to direct the Division's fundamental and applied research on combustion centred on problems of importance to the future development of combustion and total gasification processes using Australian coals. The work is concerned with the rheological properties of slag and clinkers, and the nature and mechanism of formation and prevention of external deposits on the heating surfaces of boilers. The combustion phenomena in cupolas and improvement of efficiency and performance of cupolas in iron foundries is also being investigated on a technical scale in well equipped laboratories supported by a wide range of physical-chemical apparatus for fundamental studies.

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Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No: 480/354), should be addressed by March 4, 1961.

AUSTRALIA
COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

APPOINTMENT OF CHIEF, DIVISION OF MINERAL CHEMISTRY

Applications are invited for the position of Chief of the Organization's Division of Mineral Chemistry, Chemical Research Laboratories, Fishermen's Bend, in succession to Mr. R. G. Thomas, who is about to retire.

The Division is concerned with the chemistry of minerals and their derivatives and thus includes phases of mineralogy, pure and applied inorganic and physical chemistry, and electrochemistry. In certain projects, it collaborates freely with industry; others are of a fundamental nature. Applicants should have high academic qualifications and a considerable amount of research experience. Some experience as scientific administrator is desirable.

The Division which has an annual budget of £A.87,000 and a total staff of 32, including 16 research staff has fully equipped laboratories, free use of library, central workshops, clerical and other facilities. It has close liaison with industry, universities and other Divisions of C.S.I.R.O. The new Chief will have considerable responsibility in framing future research policy and ample opportunity to carry out personal research.

SALARY: Offered at the rate of £A.4,902 per annum.

First class fares paid. Further particulars of conditions and details of the present research programme available on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2.

to whom applications (quoting Appointment No.: 601/6) should be addressed by April 8, 1961.

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is required for the Technical Department to undertake the study of schemes for new plant of a general engineering or metallurgical character, and will be responsible for co-ordination of sales, engineering, research accountancy and production aspects.

Candidates, preferably 30–38, should have a good Honours Degree in Mechanical Engineering, Metallurgy or Natural Sciences, with some production experience. Some acquaintance with statistics and/or accountancy would be an advantage.

TWO DEVELOPMENT OFFICERS

are required for work on copper and its alloys.

One is required for the Copper Products Group to play a leading part in developing new products and in improving processes and plant for the production of copper and copper alloy tape and wire.

The other vacancy exists in the Development and Technical Services Department, to be concerned with development and after sales service in connection with new and existing wrought products in copper and copper alloys.

Candidates, preferably 28–35, should have a good Honours Degree in either Metallurgy or Mechanical Engineering with practical experience in Development work.

Salaries will depend on age, experience and qualifications with adequate scope for progressive remuneration.

There is a Staff Pension Fund and an Employees' Profit-Sharing Scheme. Assistance can be given towards house-purchase and removal expenses for married men.

Please write for an application form to the :

Personnel Manager (Staff),
IMPERIAL CHEMICAL INDUSTRIES LIMITED,
Metals Division,
P.O. Box 216,
Kynoch Works,
WITTON,
Birmingham 6.

IMPERIAL CHEMICAL INDUSTRIES LIMITED
DYESTUFFS DIVISION

has a vacancy in the RESEARCH DEPARTMENT at MANCHESTER for an

HONOURS GRADUATE IN MATHEMATICS

to expand the application of mathematics in the many fields of the Division's interests and activities. The principal qualification is the ability to apply constructive mathematical thought and technique to chemical and physical problems, some of a fundamental research character and others connected with the development of new products and the operation of processes. For a mathematician able to meet the challenge of novel applications for mathematical knowledge there is ample scope and stimulus in the activities of the most varied Division in I.C.I., with opportunity to learn and develop new techniques—e.g., in the use of digital computers. There are excellent prospects for promotion.

The Company operates a five-day, 37½ hour week; a Pension Fund and an Employees Profit Sharing Scheme. Assistance can be given towards housing and removal expenses.

Application forms may be obtained from:
The Staff Department, Hexagon House, Blackley, Manchester, 9.

ENGLISH ELECTRIC

VALVE COMPANY LTD.

Research Department

Honours Physicists and Mathematicians, particularly those with postgraduate experience, are required for positions in the Research Department of the Company at Chelmsford, Essex.

The research programme embraces studies on:

Television Camera Tubes.
Image intensifiers and Image Converters.
Novel tubes in the above field for special applications.
Semi conductor devices.

Inquiries respecting these positions should be addressed to: Dept. G.P.S., English Electric House, Strand, London, W.C.2, quoting reference N1595N.

Immunologist

(aged 23-35)

Beecham Research Laboratories Ltd. require the services of a Graduate with a background of Biochemistry or Zoology and possessing immunological experience or potential: to carry out fundamental and applied research on immunological aspects of allergy, encompassing in vitro and in vivo studies, as a member of an integrated immunochemical research team.

It is of prime importance to find the right person, who can expect the usual benefits and an adequate salary. Excellent prospects of future promotion exist with this rapidly expanding British company.

Write, giving brief details of age, qualifications and experience, to:

THE DIRECTOR,
BEECHAM RESEARCH LABORATORIES LTD
BROCKHAM PARK - BETCHWORTH - SURREY

EMPIRE COTTON GROWING CORPORATION

POSTGRADUATE STUDENTSHIPS AND DIRECT APPOINTMENTS, 1961

The Corporation, which was established under Royal Charter in 1921, carries out research and experimental work on cotton, in close co-operation with the Departments of Agriculture. The main centre of this work is the Cotton Research Station at Namulonge, near Kampala, in Uganda, but members of the staff also work on Government Experiment Stations in Aden, Kenya, Northern Nigeria, Nyasaland, the Republic of the Sudan, Tanganyika, and the West Indies.

The vacancies outlined below will be filled either by the normal method of awarding postgraduate studentships for preliminary training, or alternatively by direct appointment, at appropriate points on the salary scale, of men who already have some years' suitable postgraduate experience.

AGRICULTURAL BOTANISTS

Applicants should be graduates in agricultural botany, or graduates in botany with a desire to make their careers in agricultural research. Appointment would entail work in a team engaged in research on the genetics, breeding and physiology of the cotton plant and on its methods of cultivation. Appropriate preliminary training would be given in the studentship year, including statistics and field experimentation.

STUDENTSHIP TERMS

Applications for studentships will be accepted from men who will graduate in 1961. The studentships would start between July and October, 1961, according to the course decided upon in each individual case, and would be tenable for about a year at a University or an Institution in the United Kingdom. The value of the grants would be based on those paid to holders of similar awards by the Colonial Office; the current rates range from £35 to £43 a month, according to location, plus payment of University and tuition fees, College dues and a book allowance.

TERMS OF SERVICE

The starting salary for an honours graduate with one year's postgraduate training is £1,100, and the normal scale rises by annual increments to £2,370. In addition, there are some senior posts at £2,500, and a limited number of superscale posts at higher salaries. All the staff receive free quarters with heavy furniture. Territorial allowances are payable in Aden and the Sudan, and educational allowances varying from £90 to £200 per child per year are paid in certain circumstances.

Corporation officers are, in general, accorded the same privileges as Government officers for medical and dental treatment and are granted similar local travelling facilities and allowances.

The Corporation has its own staff assurance scheme: the rate of contribution by the officer is 5 per cent, the Corporation's contribution varying from 10 per cent for officers under 30, to 25 per cent for officers aged 50 and over with at least ten years' service.

In Aden and the Sudan leave is given annually. In other territories leave is normally taken every second year, air passages being provided for the officer, his wife and all dependent children under 19.

Applications for appointments or studentships, to be made on a form which will be supplied on request, should be posted to the Empire Cotton Growing Corporation, 12 Chantrey House, Eccleston Street, London, S.W.1, before the end of term in March, 1961, to facilitate taking up references. Candidates should be prepared to attend for interview in London in late April or early May.

UNIVERSITY OF WESTERN AUSTRALIA

SENIOR LECTURESHIP IN PHYSICS

Applications are invited for appointment to the above-named position in the Department of Physics. The salary range for the position is £A.2,450 by £A.100 to £A.2,950 per annum with superannuation similar to F.S.S.U. The construction of a new building to house the Department of Physics commenced recently and it is anticipated that the building will be ready for occupation by the middle of 1962. The appointee will be required to commence duties as early as possible.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment, before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in Australia and London on March 31, 1961.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF MATHEMATICS

Applications are invited for the post of Lecturer (£1,050 by £50 to £1,400 by £75 to £1,550 (bar) by £75 to £1,850) or Assistant Lecturer (£800 by £50 to £950), both plus £60 London allowance, in Statistics. The appointment will carry F.S.S.U. and family allowance benefits. Initial stipend will be related to qualifications and experience. Practical experience, especially in industry, will be given weight, as well as research or teaching experience.

Applications (three copies), with names of not more than three referees, should be sent by March 24, 1961, to the Head of the Department of Mathematics, Imperial College of Science and Technology, London, S.W.7, from whom further particulars may be obtained.

GOVERNMENT OF WESTERN NIGERIA

VACANCY FOR CHIEF

AGRICULTURAL RESEARCH OFFICER

Applications are invited from suitably qualified candidates for the post of Chief Agricultural Research Officer.

Qualifications: Candidates must have a First- or Second-class Honours degree in Natural Science or Agricultural Science, and should have considerable research experience in tropical agriculture. Essential that applicants have shown aptitude for direction of research.

Duties: The successful candidate will be required to plan, organize and develop the work of the Research Division of the Ministry of Agriculture and Natural Resources, assist in the formulation of crop research policy and to advise the Agricultural Extension Services of the Region on the application of research findings to crop production problems.

Terms of Appointment: Considering the level of this appointment, the salary attached to it is subject to negotiation and candidates are invited to indicate the minimum salary that would be acceptable to them. Applicants should set out on the prescribed form a detailed record of his experience. Leave will be at the rate of seven days for every completed month of service and free passages are provided once every tour of 12 to 15 months for the officer, his wife, and two children below the age of 18. Free medical treatment for officer and his family; furnished quarters at low rentals.

Applications should be completed in triplicate on the prescribed form obtainable from the Official Secretary (Recruitment Branch), Office of the Agent-General, Western Region of Nigeria, 17a/202, Great Portland Street, London, W.1, from whom further particulars may also be obtained.

Closing date: February 25, 1961.

MAKERERE COLLEGE

THE UNIVERSITY COLLEGE OF EAST AFRICA

Applications are invited for (A) Readership or (B) Senior Lectureship in Agricultural Chemistry. Candidates should have a wide knowledge of agricultural chemistry and possess an honours degree in chemistry or agricultural chemistry with research experience in some aspect of biochemistry or nutrition. Salary according to qualifications and experience within scales: (A) £1,974 to £2,724 per annum (B) £1,950 to £2,475 per annum. F.S.S.U. Child allowance £50 per annum per child (maximum £150 per annum). Passages for appointee and family (up to four adult passages) on appointment, termination and leave (three months every 21 months). Rent (including basic furniture) according to quarters provided £45 to £84 per annum.

Detailed applications (six copies), naming three referees, by March 17, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

Weir

RESEARCH DEPARTMENT

The exploitation of sea water as a source of fresh water and the utilization of the dissolved salts, is entering a period of rapid expansion and G. and J. WEIR LTD., is an acknowledged leader in the design and development of sea water evaporators and other demineralization equipment. The study of these problems is of immense importance throughout the world.

This Company requires for its Research Department a Chemist or Chemical Engineer with honours degree in physical chemistry, inorganic chemistry or chemical engineering, and with an interest in ionic solutions, to carry out theoretical and experimental investigations into sea water demineralization.

The Research Department also requires a Fluid Dynamicist with honours degree in mathematics, physics, chemical engineering or mechanical engineering, and with an interest in fluid dynamics and boundary layer theory, to carry out mathematical investigations into flow through centrifugal machinery. Some experience of modern computer techniques would be useful.

The above positions are permanent, superannuated and carry a free life insurance. Salary commensurate with experience.

Apply to:

Personnel Manager,
G. & J. Weir Ltd.,
Cathcart, Glasgow, S.4.

ENGLISH ELECTRIC VALVE CO. LTD.

Chelmsford, Essex

A Physicist or Mathematician is required for research on electron optical systems.

Applicants should possess a first- or second-class honours degree in physics or mathematics, and be preferably within age range 22 to 30.

Salary will take into account age and any previous relevant experience.

Apply to Department G.P.S., English Electric House, Strand, London, W.C.2, quoting reference N1595P.

ICI

PHOTOGRAPHIC TECHNOLOGY

A vacancy has arisen in the Research Headquarters of IMPERIAL CHEMICAL INDUSTRIES LIMITED, DYESTUFFS DIVISION,

for a

CHEMIST OR PHYSICIST

for research and development involving the application of diverse scientific skills in novel fields of photographic technology. Applicants, preferably under 30 years of age, should have a good Honours degree; experience in postgraduate research or in a field of science applicable to the technology is desirable.

Applications, giving brief details of qualifications and experience, should be addressed to the:

Staff Manager, Hexagon House, Blackley, Manchester, 9,
quoting reference T/64/N.

ENGLISH ELECTRIC VALVE COMPANY LIMITED

Microwave Research and Development

The Company has considerable effort engaged on research and development into very low noise microwave tubes.

Physicists and engineers are required to assist in this programme and whilst we would prefer graduates with experience in this field of activity we would be pleased to hear from graduates with good honours degrees backed up with industrial experience in light electrical or electronic companies.

Employment would be at the Company's Works in Chelmsford, Essex.

Inquiries should be addressed to: Group Personnel Services, English Electric House, Strand, London, W.C.2, quoting reference N1506K.

SUGAR RESEARCH INSTITUTE QUEENSLAND

DIRECTOR

Applications are invited for the position of Director of Research of one of the world's leading sugar milling research institutes. It is owned by the sugar mills of Queensland, and has, in the 11 years of its operation, contributed markedly to the present high level of technical performance of the industry.

Applicants should have a higher University degree, and possess the experience which would fit them to administer an active and progressive scientific institute, the functions of which are to carry out research in all problems of raw sugar manufacture. These embrace both basic and technological investigation in the chemical, engineering and physical fields.

This is a position of high influence and status in a major industry of Australia and commensurate salary and conditions of service will be determined for a suitable appointee.

Applications, accompanied by names of referees, should be submitted to:

Chairman of Directors,
Sugar Research Institute,
P.O. Box 21,
Mackay, Australia.

UNIVERSITY OF QUEENSLAND

SENIOR LECTURER IN APPLIED MATHEMATICS

Applications are invited for the above-mentioned position. Applicants should have an Honours Degree in Mathematics, and preferably a higher degree and some experience of research. The salary range is £A.2,520 by £A.70 to £A.2,870. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on February 25, 1961.

COUNTY BOROUGH OF BRIGHTON EDUCATION COMMITTEE

BRIGHTON TECHNICAL COLLEGE

Required from April 1, 1961. Senior Technician in Physics Department (for servicing electronics equipment). Qualification: appropriate H.N.C. or C. and G. Final Certificate or equivalent. Salary £625 by £20 (3) by £25 (3) to £760.

Further particulars and application forms (returnable by February 18) from the Registrar, Brighton Technical College, Richmond Terrace, Brighton, 7.

W. G. STONE,
Director of Education.

54 Old Steine,
Brighton.

WESTFIELD COLLEGE

(UNIVERSITY OF LONDON)
DEPARTMENT OF ZOOLOGY

Applications are invited from men and women graduates for the posts of Lecturer and Assistant Lecturer. Preference may be given to applicants for the Lectureship with an interest in physiology or ecology. Salary scales: Lecturer, £1,050 by £50 to £1,400 by £75 to £1,850 per annum plus London allowance (£60) with an efficiency bar at £1,550; Assistant Lecturer, £800 by £50 to £950 per annum plus London allowance (£60). The appointments, with benefit of family allowances and superannuation (F.S.S.U.), will date from October 1, 1961, or such earlier date as may be arranged.

Further particulars may be obtained from the Secretary to Council, Westfield College, Hampstead, London, N.W.3, to whom applications (six copies), stating age, qualifications and experience, together with the names of three referees, should be submitted by first post on Monday, March 6.

MACAULAY INSTITUTE FOR SOIL RESEARCH

Applications are invited for the appointment of a Soil Survey Officer (male) for the Soil Survey of Scotland. Candidates should possess a first- or second-class honours degree in science. The appointment will be made in the Scientific Officer grade, starting salary within the range £710 to £1,175 according to age, qualifications and experience. Superannuation under F.S.S.U.

Forms of application may be obtained from the Secretary, The Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, to whom they should be returned before February 28, 1961.

COLLEGE OF AERONAUTICS

Lecturer in Metallurgy required in Department of Materials, preferably with a special interest in deformation and fracture and with knowledge of solid mechanics. Experience in some industrial field would be an advantage. The person appointed will be expected to carry out research, and to assist in directing the work of postgraduate students. Salary in scale £1,050 by £50 to £1,400 by £75 to £1,850 per annum, with superannuation under F.S.S.U. and family allowance, commencing salary depending upon age, qualifications and experience. Consideration given to housing requirements.

Applications, giving full particulars and the names and addresses of three referees, should be forwarded to the Recorder, the College of Aeronautics, Cranfield, Bletchley, Bucks. Further particulars available.

UNIVERSITY COLLEGE OF WALES

ABERYSTWYTH

Applications are invited for the post of Assistant Lecturer in the Department of Agricultural Botany to take up duties on October 1, 1961. Applicants should possess a good honours degree in either Botany or Agricultural Botany and should have a special interest in Mycology or Plant Pathology. Salary scale: £800 by £50 to £900, under 26 years of age on appointment, £850 by £50 to £950, over 26 years of age on appointment, plus superannuation benefits and children's allowances.

Further particulars can be obtained from the Registrar, to whom applications should be sent, together with the names of two persons to whom reference may be made, not later than February 18, 1961.

THE BRITISH CERAMIC RESEARCH Association has vacancies for Chemists or Physicists to work in the Pottery Section of the Association. There is also a vacancy for an Organic Chemist to work primarily on adhesives and grouting materials. Good laboratory facilities are available. The post is permanent and progressive and carries superannuation provision under the Federated Superannuation System for Universities. Salary will depend on age, qualifications and experience, but will be in the range of £720 to £1,090 for a Scientific Officer, and £1,100 to £1,600 for a Senior Scientific Officer.—Applications, giving details of age, qualifications and experience, should be sent to the Director, The British Ceramic Research Association, Queens Road, Penkhull, Stoke-on-Trent.

SENIOR TECHNICIAN OR TECHNICIAN to join research team investigating biochemical mechanisms in wound healing. Qualifications A.I.M.L.T., F.I.M.L.T. or equivalent with experience of biochemical procedures.—Applications by February 11, to G. T. Watts, Esq., Surgery Department, Clinical Research Unit, Queen Elizabeth Hospital, Birmingham 15.

UNIVERSITY OF AUCKLAND
NEW ZEALAND
LECTURESHIP IN PSYCHOLOGY

Applications are invited for the above-mentioned post. Applicants should possess postgraduate qualifications and have had research or clinical experience; in addition to competence in general psychology, experience in psychometrics and/or applied experimental psychology would be desirable. The successful applicant would be required to lecture at all stages including honours. The salary scale is £1,250 per annum, rising to £1,700 by annual increments of £75 each. Commencing salary within this scale will be determined according to qualifications and experience. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on March 15, 1961.

GOVERNMENT OF WESTERN NIGERIA

VACANCY FOR

AGRICULTURAL ENGINEER

Applications are invited for the post of Agricultural Engineer.

Qualifications: A University degree in Agricultural Engineering or in Agriculture with a postgraduate qualification in Agricultural Engineering. A minimum of ten years' experience in the operation of mechanized farming schemes is essential. Experience of mechanization of arable crops is desirable.

Duties: To review present procedure and past records dealing with schemes of mechanization. To indicate possible future line of development in mechanization and to initiate any investigations required or establish schemes indicated in these proposals.

Conditions of Appointment: On contract for one or two tours of 12 to 18 months each in the first instance. Salary is between £1,554 and £2,316 per annum, according to experience since qualifying. In addition, gratuity is paid at the rate of £37 10s. for each completed three months service. Free first-class passages for officer and his family on first appointment and when proceeding on leave; free medical treatment for officer and his family. Accommodation is provided at low rentals.

Method of Application: Applications should be completed in triplicate on the prescribed form obtainable from the Official Secretary (Recruitment Branch), Office of the Agent-General for Western Nigeria, 178/202 Great Portland Street, London, W.1, from whom further particulars may also be obtained.

Closing date: February 25, 1961.

UNIVERSITY OF WESTERN AUSTRALIA
SENIOR LECTURESHIP IN MATHEMATICS

Applications are invited for appointment to the above-named position in the Department of Mathematics. The salary range for the position is £A.2,450 by £A.100 to £A.2,950 per annum with superannuation similar to F.S.S.U. The Department at present has an academic staff of two Professors, four Readers, three Senior Lecturers, seven Lecturers, two Tutors and one Graduate Assistant. Further particulars concerning the Department, including journal subscriptions, library facilities, details of courses, teaching loads, etc., may be obtained from the Chairman of the Department of Mathematics. The appointee will be expected to take up duty as soon as possible.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment, before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 24, 1961.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

PHYSICAL CHEMIST

The Organization's **Division of Food Preservation** invites applications for a position as Physical Chemist with their **Physical Chemistry Unit**, in the Biochemistry Department, University of Sydney, from Honours graduates in Science (or equivalent qualifications) and thorough postgraduate training and research experience in Physical Chemistry. Research experience with macromolecules and colloidal phenomena an advantage.

The research programme is concerned with the physical chemistry of macromolecules, including ionic relations, denaturation phenomena, and colloidal properties, with particular attention to muscle proteins. The equipment includes a Spinco Model E ultra-centrifuge and electrophoresis apparatus. The appointee will be required to initiate a programme of research within this framework.

Salary: Dependent on qualifications and experience within the ranges, £A.1,510 to £A.2,265 per annum or £A.2,395 to £A.2,720 per annum.

Salary for women will be £A.180 per annum less than corresponding rates for men.

Promotion within C.S.I.R.O. is by merit and may ultimately go beyond the upper limit of the scale within which the original appointment is made.

Fares paid. Further details may be obtained on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 300/241) should be addressed by March 11, 1961.

SHELL **Shell Chemicals**

require for Carrington Research Laboratory (near Manchester)

RESEARCH CHEMISTS

Applications are invited for the following vacancies:

For RESEARCH ON THERMOPLASTICS

1. Chemist or Plastics Technologist to study the formulation, processing and physical properties of new and experimental high polymers.
2. Chemist to work in the field of olefin polymerisation with Ziegler catalysts.

For RESEARCH ON GENERAL INDUSTRIAL CHEMICALS

1. Physical Chemist to work on reaction kinetics and reaction mechanisms.
2. Organic Chemist for research on polyurethanes.
3. Organic Chemist for exploratory and long range research.
4. Chemist to work on process development of heavy organic chemicals on laboratory and pilot plant scale.

Applicants should have Ph.D. or good Honours Degree with research experience. Age preferably not over 35.

These are important career appointments and salaries will be commensurate with qualifications and experience. Generous pension scheme and other benefits.

Write, with full particulars (quoting reference CRL 129), to:

SHELL CHEMICAL CO. LTD.,
PERSONNEL DEPARTMENT
29/30 Old Burlington Street, London, W.1.

KENYA
AGRICULTURAL CHEMIST

To take charge of research projects into soil and plant nutrition problems of coffee. Candidates must have a good honours degree in agricultural chemistry or chemistry with at least two years' postgraduate research experience in agricultural chemistry. Appointment on probation for permanent establishment with pensionable emoluments in scale £981 to £1,863 per annum. Free passages on appointment and leave for officer, wife and children up to equivalent of three adult passages in all. Furnished quarters, usually available, at moderate rental.

Apply, stating full name and giving brief particulars of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1. Quoting BCD.63/7/050/C1.

UNIVERSITY OF QUEENSLAND
LECTURER IN BOTANY

Applications are invited for the above-mentioned position. The appointee should be prepared to deliver lectures in Botany I and to present an undergraduate course in Plant Anatomy to students in the Faculties of Science and Agricultural Science. The salary is £A.1,830 by £A.70 to £A.2,330. The successful applicant will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.

Further particulars and application forms may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 15, 1961.

UNIVERSITY OF LIVERPOOL

Applications are invited for the following posts in the Department of Physics. (a) Leverhulme Fellow and Lecturer. The initial salary will be within the range £1,050 to £1,650 per annum, depending upon age and experience. The post is specially for research and teaching duties are limited. The holder will take part in high or low energy nuclear physics research, using either a 400 MeV. synchro-cyclotron or a 12 MeV. tandem Van der Graaff electrostatic generator. (b) Three posts of Assistant Lecturer or Lecturer. The initial salaries will be in the range £900 to £1,650 per annum for one post, and in the range £900 to £1,350 per annum for the other two. Each post carries normal teaching duties, and the holder will take part in research in one of the three following fields. (i) High energy physics using a 400 MeV. cyclotron. (ii) Low energy nuclear physics using a 12 MeV. tandem Van der Graaff electrostatic generator. (iii) Acoustics.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than March 1, by the Registrar, from whom further particulars of the conditions of employment may be obtained. Ref: CV/N.

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

LECTURER IN ELECTRICAL ENGINEERING

Applications are invited for the above-named position. Applicants should hold a university degree in electrical engineering and have subsequent experience in research, in teaching, or in industry. A knowledge of the fundamentals of nuclear engineering is also essential. Duties will include lecture, tutorial and laboratory work in an electrical engineering department which embraces both the power and electronic sides of the subject. The successful candidate will also be required to assist in the introduction of short lecture courses on nuclear engineering and contribute to the installation and operation of a compact but well equipped nuclear engineering laboratory with a sub-critical reactor as its central feature. Adequate facilities and time for research will be provided. The salary scale is £1,250 to £1,700 per annum.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close on February 28, 1961.

WARWICKSHIRE EDUCATION COMMITTEE

RUGBY COLLEGE OF ENGINEERING TECHNOLOGY

(Principal: G. S. Atkinson, B.Sc., Ph.D.)

Extension of full-time (sandwich) Engineering and Science Courses leading to Diplomas in Technology and External Degrees is taking place, and applications are invited for the following posts. Normal teaching duties will be concerned with full-time (sandwich) degree and diploma students, and there will be excellent opportunities for research.

Senior Lecturer in Mathematics. A high level of mathematical ability together with experience of teaching mathematics to advanced students is required. The person appointed should be interested in the development of new ideas in the teaching of mathematics to physicists.

Lecturer in Mathematics. A high level of mathematical ability is required and teaching experience is desirable.

Lecturer in Electrical Engineering. Applicants for this post in light and heavy current work need not have extensive teaching experience, but a university degree, together with good industrial or research experience, is expected.

Salaries (Burnham Scale): Senior Lecturers, £1,550 by £50 to £1,750. Lecturers, £1,370 by £35 to £1,550.

Further particulars and application forms from the Principal, Rugby College of Engineering Technology, Eastlands, Rugby, to whom replies should be sent not later than February 17, 1961.

N. A. Y. YORKE-LODGE,
County Education Officer.

METROPOLITAN BOROUGH OF ST. MARYLEBONE

MEDICAL LIBRARIAN—PUBLIC LIBRARIES

Applications are invited for a new appointment as Librarian-in-Charge of the Special Medical Collection (Metropolitan Boroughs Special Collections Scheme). Salary in accordance with Grade APT. II, minimum £840 per annum (£855 if aged 26 or over), rising to £1,000 per annum. Candidates must be Chartered Librarians with suitable experience. Permanent superannuable appointment.

Application form and further details of appointment from Establishment Officer, Town Hall, St. Marylebone, W.1. Completed applications must be returned by noon on Monday, February 20, 1961.

SENIOR PHYSICISTS

Due to the expansion of the Physics Section of the Research Department, Senior Physicists are required by Cambridge Instrument Company, Ltd., in their well equipped new laboratories in the University City of Cambridge.

THE MEN Should possess a good honours degree, or corporate membership of an appropriate institution together with suitable experience.

THE JOB Responsibility for sections working on further developments of electron probe microanalysis, scanning X-ray microscopes and kindred techniques, or for work on classical physics and electronics (including circuit design)—in fact a wide range of subjects with ample opportunities for developing particular interest. The work will entail investigation of physical phenomena and their application to the development of measuring and control instruments for industry and research. In addition there will be opportunities for contact and co-operation with universities and other research organizations.

SALARY & PROSPECTS The ***prime factor*** is to find the right men. Together with the usual benefits, they can expect an attractive starting salary with excellent prospects. Housing assistance scheme available.

Write in confidence, giving details of age, experience and qualifications to :

Dr. M. C. Marsh

CAMBRIDGE INSTRUMENT CO. LTD.

CHESTERTON ROAD CAMBRIDGE

THE DISTILLERS COMPANY LIMITED

ASSISTANT CHEMICAL BUYER

The Company wishes to appoint an Assistant Chemical Buyer in the London Head Offices of the Chemical Division.

The person appointed will be responsible for obtaining quotations for a wide range of chemical products required by the Chemical Division factories; for checking the specifications, prices and suitability of these, and for placing the final orders and arranging the delivery programmes.

During the course of his duties, the new person will be expected to become familiar with the manufacture, packing, transport and insurance of the products bought by the Chemical Division, and where imported materials are concerned familiarization with customs regulations and tariffs will be necessary.

Candidates, aged not over 30, should have a degree or its equivalent in science preferably with Chemistry as the main subject. Previous experience would be useful but is not essential.

Write :
STAFF MANAGER
THE DISTILLERS COMPANY LIMITED
21/22 BOLTON STREET
LONDON, W.1.

Quote Ref. 5/61N.

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL

(UNIVERSITY OF LONDON)

UNIVERSITY STREET, LONDON, W.C.1

BEIT MEMORIAL FELLOWSHIPS FOR MEDICAL RESEARCH

Notice is hereby given that an election of Junior Fellows to begin work on October 1 next will take place in May, 1961. Junior Fellowships have successive annual values of £900, £950 and £1,000 for three years. As a rule, superannuation benefits are provided, to which the successful candidates will be required to contribute 5 per cent of the annual stipend and to which the Trust will make a contribution of 10 per cent. Candidates must have taken a degree in a faculty of a university approved by the Trustees in Her Majesty's Dominions, Protectorates and Mandated Territories, India, Pakistan and the Republic of Ireland, or a medical diploma registrable in the United Kingdom. Elections to Junior Fellowships are rarely made above the age of thirty-five years. Applications from candidates must be received not later than April 1. Candidates must submit evidence that they can be given accommodation in the departments where they propose to work, which must be either in Great Britain or Ireland.

Forms of application and all information may be obtained by letter only, addressed to Sir Roy Cameron, F.R.S., Beit Memorial Fellowships for Medical Research, University College Hospital Medical School, University Street, London, W.C.1. For Overseas Candidates forms of application may be obtained from the Secretary, South African Medical Council, P.O. Box 205, Pretoria, South Africa; The Ministry of Health, The Government of India, New Delhi, India; The Government of East Pakistan, Eden Buildings, Ramna, Dacca, East Pakistan; The Director, Commonwealth Office of Education, Box 3879, Sydney, Australia; The Department of Health, Wellington, New Zealand; and The Canadian Medical Association, 244 St. George Street, Toronto, Canada.

RESEARCH ASSISTANT WANTED AT Stoke Mandeville Hospital to help with current research on an immunological project connected with Rheumatoid Arthritis. The person appointed would work directly with the Pathologist undertaking the research. Salary £750 to £1,000 per annum according to qualifications.—Inquiries and applications, giving details of experience and the names of two referees, to the Pathologist, Stoke Mandeville Hospital, Aylesbury, Bucks.

AUSTRALIA

UNIVERSITY OF NEW SOUTH WALES
DIRECTOR OF DIGITAL COMPUTING LABORATORY
SCHOOL OF ELECTRICAL ENGINEERING

The University invites applications for appointment to the position of Director of the Digital Computing Laboratory, within the School of Electrical Engineering. Salary: £A.4,000 per annum. Applicants must possess a higher degree, and should have had experience in the field of digital computers. The Director will be responsible to the Head of the School of Electrical Engineering, Professor R. E. Vowels, for the operation of the laboratory, and also may be required to lecture in the field of computers. At present the laboratory contains an English Electric DEUCE Computer (UTECOM), which provides a service within the University, and also services other universities, government departments and industries throughout Australia. The laboratory has also conducted courses in programming and numerical analysis. The staff of the laboratory contributes to the lecture programme in the field of computing. Subject to satisfactory medical examination the successful applicant will be eligible to contribute to the State superannuation scheme. The successful applicant will be eligible for six month's study leave on full salary after three years of service, or twelve months after six years of service. First-class ship fares to Sydney of appointee and family will be paid. With the approval of the University and its bankers married men may be assisted by loans to purchase a home. The University reserves the right to fill the position by invitation.

Four copies of applications, including the names of three referees, should be lodged with the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, the University of New South Wales, Box 1, Post Office, Kensington, N.S.W., by airmail to reach there before March 10, 1961.

UNIVERSITY OF WESTERN AUSTRALIA

SENIOR LECTURESHIP IN ELECTRICAL ENGINEERING

Applications are invited for appointment to the above-named position for which the salary range is £A.2,450 by £A.100 to £A.2,950 per annum with superannuation similar to F.S.S.U. Preference will be given to candidates with an interest in Electrical Machines, Electrical Measurements or Telecommunications. The Department of Electrical Engineering is housed in a well-equipped new building and there are excellent facilities for research. The appointee will be expected to take up duty as soon as possible.

It is important that intending applicants obtain details of the procedure to be followed in applying for the post and a copy of the Conditions of Appointment, before submitting their applications. This information is available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 31, 1961.

UNIVERSITY OF EDINBURGH

DEPARTMENT OF PUBLIC HEALTH AND SOCIAL MEDICINE

Applications are invited for the post of Senior Lecturer in Medical Statistics. The successful applicant, who need not be a graduate in medicine, will be expected to take part in the establishment of a Statistics Unit for the Faculty of Medicine, although based in the Department of Public Health and Social Medicine. Salary scale: £2,050 by £100 to £2,425 per annum, with placement according to qualifications and experience, and with superannuation benefit and family allowance where applicable.

Further particulars may be obtained from the undersigned, with whom applications (six copies), giving the names of two referees, should be lodged not later than April 1, 1961.

CHARLES H. STEWART,
Secretary to the University.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Applications are invited for a Lectureship in Pure Geochemistry from October 1, 1961. Salary range £1,050 to £1,850 per annum plus £60 London allowance, F.S.S.U. membership and family allowances. Candidates should have geochemical qualifications and be familiar with one or more of the following techniques: optical or X-ray spectrography, silicate or radioactive analysis.

Apply to Professor D. Williams, Department of Geology, Imperial College of Science and Technology, London, S.W.7.

NATURE

Applications are invited for a post on the editorial staff of NATURE.

A university degree in science or technology is essential, and preference will be given to a candidate who has worked in science or industry for at least two years since graduation.

Particulars and references should be sent to: The Manager, *Nature* Office, Macmillan and Co. Ltd., St. Martin's Street, London, W.C.2.

CENTRAL ELECTRICITY GENERATING BOARD

BERKELEY NUCLEAR LABORATORIES

HEALTH PHYSICS GROUP

Applications are invited for two appointments in the Health Physics Group at the Berkeley Nuclear Laboratories, which are situated midway between Bristol and Gloucester.

(a) Duties will be to arrange and take part in detailed radiation surveys of the Laboratories, assisted by a small team of monitors. The work involves preparation of reports and keeping records of radiation levels. The successful applicant will work under the general supervision of the Assistant Health Physicist, but scope exists for personal initiative. For this post, applicants must have a good general education and preferably experience in similar posts. Candidates without such experience will be considered if they possess a pass degree or equivalent qualifications and have a keen interest in routine health physics.

(b) Duties will be to organize and supervise the technical services in the Health Physics laboratory under the direction of research staff. The work will include the evaluation, assembly, construction, maintenance, and calibration of health physics equipment, together with maintenance of relevant technical records. The qualifications for this post include a good general education, with proven ability in technical supervision. Some experience in electronics or health physics would be an advantage.

Salaries within the range £955 to £1,245 per annum.

Applications, stating age, qualifications, experience, present position and salary, to the Appointments Officer, 24/30 Holborn, London, E.C.1, by February 17. Envelopes should be marked "Confidential Ref. N/41."

UNIVERSITY OF ALBERTA

DEPARTMENT OF CHEMISTRY
POSTDOCTORAL RESEARCH APPOINTMENTS

$6,000 per annum, tenable for a period of one to two years, in the areas of organic, physical organic, theoretical and physical chemistry.

Apply: H. E. Gunning, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada.

OXFORD UNIVERSITY COMPUTING Laboratory invite applications for the Ferranti Fellowship in Computing, for one or two years from October 1, 1961. The successful candidate, who should have at least two years' research experience, will be expected to do original work in any field connected with computation or other application of digital computers, and will have access to a Ferranti Mercury. The Fellowship is open to candidates of any nationality, has a stipend of £900 per annum, and is subject to the provision of F.S.S.U., where applicable.—Applications, with details of academic and research experience, and the names of two referees, should be sent before July 31, 1961, to the Director, University Computing Laboratory, 9 South Parks Road, Oxford.

UNIVERSITY OF ADELAIDE

The University invites applications for the following new posts:

In the Faculty of Science, Reader in Mathematics (Applied Mathematics). Senior Lecturer in Mathematics (Mathematical Statistics). Lecturers in Biochemistry, Geology, and Physical or Inorganic Chemistry.

At the Waite Agricultural Research Institute, Senior Lecturer in Electron Microscopy. Lecturer in Virus Chemistry. Lecturer in Species Studies in the Department of Agronomy.

Salary scales: Reader, £A.2,950 by £A.70 to £A.3,230; Senior Lecturer, £A.2,450 by £A.90 to £A.2,900; Lecturer, £A.1,675 by £A.95 to £A.2,340; with superannuation on the F.S.S.U. basis. The initial salary may be fixed within the appropriate scale in accordance with the successful candidate's qualifications and experience. Further information: (a) The Calendar of the University may be consulted in the Library of any University which is a member of the Association of Universities of the British Commonwealth or at the office of the Association. Inside the covers are the plans of the University buildings and site and of the Waite Agricultural Research Institute at Glen Osmond (four miles from the University). (b) A potential candidate for any post should also seek from the Registrar of the University or from the Secretary, A.U.B.C., 36 Gordon Square, London, W.C.1, the following documents: (i) General Conditions of Appointment, which includes particulars of tenure, superannuation, removal expenses, invalidity and study leave; (ii) a statement giving further particulars of each post and of such matters as help in housing, conference grants and special support for research. (c) The University will gladly supply any further information desired on request to the Registrar.

Applications, in duplicate, should give the information listed in the final paragraph of the General Conditions of Appointment, and should reach the Registrar, the University of Adelaide, Adelaide, South Australia, not later than February 28, 1961.

CENTRAL ELECTRICITY GENERATING BOARD

MIDLANDS DIVISION

Applications are invited for the post of Statistical Assistant in the Divisional Laboratory situated at Nechells "A" Power Station. The duties associated with this post will include the design and analysis of experimental trials and the preparation and maintenance of quality control charts. Preference will be given to candidates having a knowledge of chemistry, particularly relating to fuels. Candidates should possess a statistical qualification or hold a suitable degree in mathematics, but favourable consideration would be given to candidates who are Associates or Corporate Members of the Institute of Fuel and who have a good knowledge of statistics. The salary will be in accordance with the N.J.B. Agreement, Schedule B, Class BX, either Grade 7, £1,200 to £1,500 per annum, or Grade 6, £1,285 to £1,610 per annum, according to qualifications and experience.

Applications, quoting vacancy number 15/61 MD, to the Establishments Officer, 53 Wake Green Road, Moseley, Birmingham, 13, by February 10, 1961.

D.S.I.R. RADIO RESEARCH STATION, Slough, Bucks, requires: Experimental Officers/Assistant Experimental Officers with background in physics, electronics, and applied mathematics for work concerned with experiments on the ground, and in rockets and satellites, to investigate upper atmosphere and space between earth and sun, with particular reference to propagation of radio waves through these regions, and associated problems of terrestrial and space communications. It involves design and use of radio equipment of various kinds including low-noise amplifiers for use with radio telescope. Qualifications: G.C.E. "A" level in two science or science and mathematics subject or equivalent. Over 22 pass degree, H.N.C. or equivalent generally expected. Salary: Experimental Officer, £1,057 to £1,296; Assistant Experimental Officer, £450 10s. (age 18) to £625 (age 22) to £957.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.24/1A. Closing date February 18, 1961.

GEOLOGISTS. FOUR POSITIONS AVAILable to teach in the fields of mineralogy, petrology petrography, paleontology, stratigraphy, structural geology, economic geology and geophysics. Good opportunities for research. Adequate salary. Two-year contract, renewable.—Inquiries, with complete credentials, to Escola de Geologia, Universidade da Bahia, Salvador, Bahia, Brazil. Courses in Portuguese, Spanish, English or French.

CHEMIST FOR FINE CHEMICALS/ PHARMACEUTICALS ANALYSIS

A qualified chemist is required to investigate and develop new analytical test methods in the field of synthetic drugs. The position, which is in the Research Organization of the Smith and Nephew Group, involves close collaboration with the team of Organic and Pharmaceutical Chemists engaged in the development of chemotherapeutic products. The Laboratories, which are located in a country district 25 miles north of London, are well equipped with modern instrumental methods of analysis.

Applicants should be under 35 years and have an honours degree in chemistry, or at least Graduate Membership of the Royal Institute of Chemistry. Salary will be according to age, qualifications and experience.

There is a Contributory Pension Scheme and working conditions are in accordance with modern practice. Write, giving full details of experience, age and salary required, to:

Research Manager (Administration),
Smith & Nephew Research Limited,
Hunsdon Laboratories,
Ware, Herts.

UNIVERSITY COLLEGE OF SWANSEA

LECTURESHIP OR ASSISTANT LECTURESHIP IN BOTANY

Applications are invited for the above post from candidates with a special interest in plant physiology or biophysics. The appointment will date from October 1, 1961. The person appointed will assist in the teaching of plant physiology and take particular responsibility for the supervision of practical classes in this subject. Salary scales: Lectureships, £1,050 to £1,850 per annum; Assistant Lectureships, £800 to £950 per annum. F.S.S.U. benefits and family allowances.

Further particulars can be obtained from the Registrar, University College, Singleton Park, Swansea, by whom applications (six copies) must be received not later than Saturday, March 11, 1961.

UNIVERSITY COLLEGE OF SWANSEA

TECHNICAL OFFICER IN THE DEPARTMENT OF BOTANY

Applications are invited for the post of Technical Officer to be responsible for the general supervision and maintenance of the laboratories and the control and training of technical staff in the Department of Botany. Applicants should have a University degree in science or equivalent qualification, and be interested in the application and development of techniques for teaching and research in Botany and/or Biochemistry. The appointment will be on the scale £700 by £50 to £1,050 (bar) by £50 to £1,300. Superannuation under F.S.S.U. and family allowances.

Applications (six copies) must reach the Registrar, from whom further particulars can be obtained, not later than Saturday, March 11, 1961.

ASSISTANT CHEMIST REQUIRED FOR interesting work in new Analytical Laboratories. Minimum qualifications G.C.E. "O" level in chemistry, physics, and mathematics. Previous industrial laboratory experience an advantage but not essential. Maximum age 22. Salary according to age, qualifications, and experience. Opportunity for future part-time study at approved courses. Good conditions of employment and pension scheme. Canteen facilities available and lodging accommodation arrangeable.—Write, giving full particulars (quoting reference No. 1602), to Personnel Manager, Fisons Pest Control Ltd., Harston, Cambridge.

AGRICULTURAL RESEARCH COUNCIL requires an honours graduate (Biochemist) with some research experience, for one year in the first instance with possible extension, to assist Dr. R. M. C. Dawson on isotopic studies on lipid metabolism in rumen micro-organisms and in the ruminant digestive tract. Salary in range £717 to £1,150 according to qualifications and experience. F.S.S.U.—Applications to the Secretary, Institute of Animal Physiology, Babraham, Cambridge, within three weeks.

SARAWAK

SOIL SURVEYOR

To carry out soil surveys. Candidates, between 26 to 40, must have a degree in natural science or geography with two years training or experience in soil survey work. Appointment on contract with gratuity, or, if preferred, on probation for permanent establishment. Emoluments in range £1,344 to £2,324. Contract gratuity at the rate of 12½ per cent of salary. Outfit allowance £60. Children's allowances. Education allowances. Free passages on appointment and leave for officer, wife and up to three children under 18. Furnished accommodation, usually available. Generous leave.

Apply, stating full name and giving brief particulars of qualifications and experience, to Director of Recruitment, Colonial Office, London, S.W.1. Quote BCD.63/24/07/CI.

UNIVERSITY OF ST. ANDREWS

DEPARTMENT OF PHARMACOLOGY AND THERAPEUTICS

Applications are invited for the post of Research Assistant in Endocrinology tenable in the laboratories of the Clinical Investigation Unit, Maryfield Hospital, Dundee. The appointment is available after March 1, 1961. Salary scale £710 by £25 per annum to £870; placing according to qualifications.

Apply, giving names of three referees, to Joint Clerk to the University Court, Queen's College, Dundee, not later than February 28, 1961.

UNIVERSITY OF NEW ENGLAND

ARMIDALE, NEW SOUTH WALES SENIOR LABORATORY TECHNICIAN—LABORATORY TECHNICIAN

Applications are invited for a position of Senior Laboratory Technician—Laboratory Technician in the Department of Agronomy in the Faculty of Rural Science. The successful applicant will be required to assist with the laboratory work of the department and to attend experimental plants growing in controlled environmental conditions. The commencing wage will be fixed according to qualifications and experience, up to £A.26 5s. 9d. per week for males, and £A.22 8s. 10d. for females for Laboratory Technicians, and up to £A.30 2s. 8d. per week for Senior Laboratory Technicians. Four weeks annual leave; liberal sick leave and long service leave. Fares will be paid and removal expenses up to £A.200. In-service training may be undertaken towards a diploma in Science Technology.

Applications from within Australia and New Zealand should be forwarded to reach the undersigned not later than February 28, 1961, while applicants outside Australia and New Zealand should forward their applications to the Secretary, the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, by the same date. In the case of these applicants an additional copy should be forwarded by airmail to the undersigned. Applications should give full particulars of qualifications and experience, together with the names of two referees.

T. C. LAMBLE,
Registrar.

University of New England,
Armidale, N.S.W., Australia.

D.S.I.R. ROAD RESEARCH LABORATORY, Harmondsworth, Middlesex, requires Civil Engineers, Mathematicians, Statisticians in Senior Scientific and Scientific Officer Grades for work in Tropical Section of Laboratory. Qualifications: First- or second-class honours degree. For senior Scientific Officer posts (minimum age 26) at least three years' postgraduate experience is required, either in research or in a related field. Duties: Concern road building in countries in tropical and sub-tropical belts, involving traffic engineering and the economics of road transport generally, and road safety in these regions. Section is based at Harmondsworth and work involves regular visits overseas with, in some instances, postings for periods of one to two years on specific projects. Salary: Within range Senior Scientific Officer, £1,330 to £1,640; Scientific Officer, £730 to £1,205. Normal prospects of promotion in mid-thirties (range up to £2,375) with possibility of higher posts.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting ref. No. E.512/OA.

THE AGRICULTURAL RESEARCH COUNCIL require an Assistant Experimental Officer at their Low Temperature Research Station to work on physical problems on the processing of foodstuffs. Pass degree in Physics or Physical Chemistry or H.N.C. or equivalent qualification essential. Salary according to age in scale £645 (age 22) to £983. Contributory superannuation scheme.—Application forms from Director, Low Temperature Research Station, Downing Street, Cambridge.

SHELL

"SHELL" RESEARCH LIMITED

have a vacancy for a

RESEARCH PHYSIOLOGIST

at their

Tunstall Laboratory, Sittingbourne, Kent

A graduate in physiology, pharmacology, veterinary science or related subjects, is invited to join a team which is investigating the effect of a wide variety of chemical substances on mammals, birds and fish. Postgraduate experience within the fields of animal behaviour, metabolism, clinical pathology, nutrition or pharmacology is desirable.

The research and technical facilities are provided in a new laboratory. Salary in accordance with age, qualifications and experience. Five-day week, staff restaurant, excellent pension scheme. Please write, giving details of qualifications and experience to:

Personnel Recruitment/R.P.,
"Shell" Research Limited,
St. Helen's Court,
Great St. Helen's,
London, E.C.3.

REPUBLIC OF THE SUDAN

Applications are invited from those suitably qualified to fill two vacancies in the Research Division of the Ministry of Agriculture, Sudan, as Senior Research Officers.

(a) Chief Entomologist (reference 4/407)
(b) Chief Agronomist (reference 4/400)
(c) Chief Pathologist (reference 4/400)

Candidates must hold an appropriate first-class honours degree. Experience of research work in the tropics is desirable but not essential. Those selected will be required to conduct research on problems of practical importance in their own particular field and assume responsibility for supervising teams of research workers. Appointment will be on long term contract, the length of which will be determined between the Ministry and the successful candidate, but in any case not less than five years. Salary will be by mutual agreement based upon the successful candidate's age qualifications and relevant experience. A variable cost of living allowance is payable and an initial outfit allowance is paid on appointment. There is no income tax in the Sudan at present. Annual leave accrues at the rate of seven days per month.

Applications should be made, in writing, giving fullest details of age, qualifications and experience, and quoting above reference, to the Appointments Section, Sudan Embassy, 3 Cleveland Row, St. James's, London, S.W.1. Closing date: February 25, 1961.

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND LECTURERS IN CIVIL ENGINEERING

Applications are invited for the above-mentioned posts. Applicants should have a degree in civil engineering of a recognized university, teaching experience at a university, or have held a responsible position in a branch of civil engineering. The salary will be at the rate of £1,250 per annum, rising by annual increments of £75 to £1,700 per annum. Commencing salary will be in accordance with qualifications and experience. Approved fares to Christchurch will be allowed for the appointee, his wife and children. In addition, actual removal expenses will be allowed within certain limits.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on March 31, 1961.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3

DEPARTMENT OF PHYSICS

The Governing Body invite applications for the post of Lecturer or Assistant Lecturer (Grade B) from Physicists with good academic qualifications and experience in experimental and theoretical physics.

The salary scales are as follows: Lecturer: Men, £1,370 by £35/£40 to £1,550. Women, £1,331 9s. to £1,550. Assistant (Grade B): Men, £700 by £27 10s. to £1,150. Women, £630 to £1,150; plus additions for training and graduate status. There is in addition a London Allowance of £38 or £51, according to age.

Particulars and forms of application from the Clerk to the Governors, to whom applications should be submitted not later than February 18, 1961.

UNIVERSITY OF LEEDS

DEPARTMENT OF CHEMICAL PATHOLOGY

Applications are invited for appointment of Analyst in the Department of Chemical Pathology. The post is comparable with the National Health Service Basic Grade Biochemist, and includes work in the Hospital Biochemistry Laboratory, with opportunity for research and study towards a higher degree. Salary on the scale £710 by £30 to £860 by £35 to £1,000 a year according to age, qualifications and experience. Candidates should have at least a second-class degree in chemistry or biochemistry, or considerable experience in analytical chemistry.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained) not later than February 25, 1961.

AUSTRALIAN NATIONAL UNIVERSITY

SCHOOL OF GENERAL STUDIES

SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for appointment to new posts in physics at the level of Senior Lecturer or Lecturer. More than one appointment may be made. The salary range for a Senior Lecturer is £A.2,400 by £A.100 to £A.2,900; and for a Lecturer, £A.1,640 by £A.90 to £A.2,360. Commencing salary will be in accordance with qualifications and experience.

Further information and the summary forms which must accompany an application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on March 4, 1961.

UNIVERSITY OF TORONTO

DEPARTMENT OF MATHEMATICS

Applications are invited for vacancies in the Applied Mathematics Section of the Department. Preference will be given to applicants with experience in quantum mechanics and fluid dynamics. Rank and salary will depend on qualifications and experience. Superannuation and removal allowances are available.

Applications should be sent to Professor D. B. DeLury, Chairman, Department of Mathematics, University of Toronto, Toronto 5, Canada.

UNIVERSITY OF ALBERTA

DEPARTMENT OF CHEMISTRY

POSTDOCTORAL FELLOWSHIPS

$5,500 tax free for 12 months, in all areas of chemistry.

Apply: H. E. Gunning, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada.

MAKERERE COLLEGE

UNIVERSITY COLLEGE OF EAST AFRICA

Applications are invited for (a) Lectureship or (b) Assistant Lectureship in the Department of Mathematics. Salary scales (a) £1,350 to £2,151 per annum, (b) £1,098 to £1,251 per annum. Entry point determined by qualifications and experience. F.S.S.U. Child allowance £50 per annum per child (maximum £150 per annum). Passages for appointee and family (up to four adult passages) on appointment, termination and leave (three months every 21 months). Rent according to quarters provided £45 to £84 per annum (including basic furniture).

Detailed applications (six copies), naming three referees, by February 28, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNITED OXFORD HOSPITALS

Applications are invited for the post of Senior Technician in charge of the Cardiac Department of the Radcliffe Infirmary, Oxford. The Department is responsible for all forms of routine investigation connected with the advanced diagnosis of cardiovascular disease. In addition, it is closely associated with a University Department and is engaged in research requiring the design of prototype equipment. Applicants from I.M.L.T., Physics or Cardiological Grades, or those with similar scientific experience. Salary scale: £710 to £905 per annum.

Apply, naming two referees, to the House Governor, Radcliffe Infirmary, Oxford.

GOVERNMENT OF WESTERN NIGERIA

VACANCIES FOR

POSTS OF ASSISTANT CONSERVATORS OF FORESTS

Applications are invited for several posts of Assistant Conservators of Forests.

Qualifications: A degree in Forestry from a recognized University in the United Kingdom.

Duties: General forestry administration of a Forest Reserve or a group of Forest Reserves. Candidates may be placed in charge of a Province, a group of Provinces or a Division and will be responsible for the detailed day-to-day administration of the forest activities within his charge.

Condition of Appointment: On contract for one or two tours of 12 to 18 months each in the first instance. Salary is between £1,200 and £2,160 per annum, according to experience since qualifying. In addition, gratuity is paid at the rate of £37 10s. for each completed three months service. Free first-class passages for officer and his family on first appointment and when proceeding on leave; free medical treatment for officer and his family. Accommodation is provided at low rentals.

Method of Application: Application should be completed in triplicate on the prescribed form obtainable from the Official Secretary (Recruitment Branch), Office of the Agent-General for Western Nigeria, 178/202 Great Portland Street, London W.1, from whom further particulars may also be obtained.

Closing date: February 25, 1961.

UNIVERSITY OF LIVERPOOL

ACCELERATOR PHYSICIST

A post of Assistant Lecturer or Lecturer is available in the Department of Physics for an accelerator physicist. The holder will take part in the further development for research of the Department's 400 MeV. synchro-cyclotron, and will also undertake normal teaching duties. Applicants must be honours graduates in physics or electrical engineering, and they should have practical experience in applied physics, electronics, or electrical engineering. The initial salary will be in the range £900 to £1,650 per annum, with F.S.S.U. benefits.

Applications, stating age, qualifications and experience, together with the names of three referees, should be received not later than March 1, by the Registrar, from whom further particulars of the conditions of employment may be obtained. Ref.: CV/N.

STOKE MANDEVILLE HOSPITAL

AYLESBURY

Assistant Biochemist required in the Area Pathology Laboratory based at the above Hospital. Applicants should possess first- or second-class honours degree in chemistry or biochemistry, or A.R.I.C. Whitley Council conditions of service. Salary £925 to £1,150 per annum after (for new entrants only) a probationary period. The post offers a wide variety of experience in a well-equipped and pleasant laboratory.

Applications, giving full details of qualifications, etc., together with names of two referees, to be forwarded to the Administrative Officer as soon as possible.

UNIVERSITY OF NEW ENGLAND

ARMIDALE, NEW SOUTH WALES

LECTURER/SENIOR LECTURER IN PURE MATHEMATICS

Applications are invited for the above-mentioned position. Commencing salary will be fixed according to qualifications and experience within the range of £A.1,730 by £A.105 to £A.2,435 for Lecturer and £A.2,550 by £A.95 to £A.3,000 for Senior Lecturer, plus a cost of living allowance at present amounting to £A.29 per annum. Provision is made for superannuation, travel and removal expenses and assistance in buying or building a house.

Further information may be obtained from the Secretary, the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on February 24, 1961.

OLDCHURCH HOSPITAL ROMFORD, ESSEX

(709 Beds)

RADIOTHERAPY DEPARTMENT

Senior Technician or Technician required for the above Department. Duties include Physics Workshop, Isotope Laboratory, Radium and Mould Room work. Instrument or Physics Workshop experience essential. Salary £570 to £710 per annum; senior grade, £710 to £905 per annum would be applicable to suitably qualified person.

Applications, quoting Ref. 17/39, giving full details, including age and experience, together with names of two referees and/or copy of testimonials to the Group Secretary, Romford H.M.C., Oldchurch Road, Romford.

RHODES UNIVERSITY

GRAHAMSTOWN, SOUTH AFRICA

PROFESSOR OF PURE MATHEMATICS

Applications are invited for the above-mentioned post from July, 1961. The salary scale is £2,200 by £100 to £2,700 per annum. A vacation savings bonus, as in the Public Service, is also payable. Previous experience and academic qualifications may be taken into account in fixing the commencing salary.

Full particulars and application forms may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in South Africa and London, on March 20, 1961.

UNIVERSITY COLLEGE OF SOUTH WALES AND MONMOUTHSHIRE

DEPARTMENT OF CHEMISTRY

Applications are invited for the post of Assistant Lecturer at a salary on the scale £850 by £50 to £950. The applicant should have special qualifications in inorganic chemistry or in physical chemistry.

Applications (six copies), giving the names of three referees, should be sent to the Registrar, University College, Cathays Park, Cardiff, from whom further particulars may be obtained. Closing date for applications, February 28, 1961.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, LONDON, S.W.3

A Scientific Assistant is required for the maintenance of physical instruments including spectrophotometers and radiochemistry equipment. Duties will also include certain routine measurements and demonstrations. The person appointed will be directly responsible to the Heads of the Departments of Chemistry and Pharmacy. Salary scale: £940 by £40 to £1,000 per annum.

Further details of the appointment available on application. Closing date for applications: February 18, 1961.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital. Physicist required in Physics Department situated in Royal Marsden Hospital, Fulham Road, S.W.3, for work with radioactive isotopes, particularly tracer techniques and whole-body counting. Appointment in Grade III (£1,050 to £1,250) or Grade IV (£850 to £950) with London weighting, children's allowance and F.S.S.U. Initial salary depends on age, qualifications and experience. Apply, with names of three referees, to the Secretary, 33 Sumner Place, S.W.7, quoting ref.: 300/G/9.

SCIENCE GRADUATE WITH EXPERIENCE in Bacteriology required for a vacancy in the Dysentery Reference Laboratory, Public Health Laboratory Service at Colindale.—Apply: The Director, Central Public Health Laboratory, Colindale Avenue, London, N.W.9.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Research Assistant in the Computing Machine Laboratory, tenable in the first instance for a period of approximately one year. Applicants should have a degree in mathematics or equivalent qualifications. The person appointed will be required to assist in research into the use and design of electronic computers. Previous experience of electronic computers is desirable but not essential. The salary will be according to age and qualifications.

Applications should be sent not later than February 11, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

POSTDOCTORATE FELLOWSHIP IN NUCLEAR PHYSICS

A National Research Council of Canada Postdoctorate Fellowship will be available in 1961-62 for experimental work in nuclear spectroscopy or related topics in the Physics Department of Queen's University. The stipend, which is tax-free, is $4,000 for a single person and $5,000 for a married male.

Inquiries should be addressed to Dr. H. W. Taylor, Department of Physics, Queen's University, Kingston, Ontario, Canada.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

RESEARCH STUDENTSHIPS IN GEOCHEMICAL PROSPECTING

Applications are invited from Geology Graduates for Research Studentships in applied Geochemistry (£600 to £800 per annum for two years) starting October 1, 1961. Successful applicants will carry out field work overseas during not more than two terms.

Apply Dr. Webb, Geology Department, Imperial College, London, S.W.7, before June 1.

UNIVERSITY OF GLASGOW

MECHAN CHAIR OF AERONAUTICS AND FLUID MECHANICS

The University Court will shortly consider an appointment to the Mechan Chair of Aeronautics and Fluid Mechanics. The Chair is a full-time appointment.

Particulars as to duties, salary and conditions of appointment may be obtained from the undersigned, with whom applications (20 copies) should be lodged, not later than March 10, 1961.

ROBT. T. HUTCHESON,
Secretary of University Court.

UNIVERSITY OF LIVERPOOL

Applications are invited for three Leverhulme Posteraduate Fellowships, two in the Faculty of Science and one in the Faculty of Engineering, tenable for one year at the value of £600, and renewable for a second year.

Applications, three copies, stating age, details of qualifications and experience, publications, research work in progress and completed, and an outline of the proposed field of research, together with the names of two referees, should be received not later than March 1, 1961, by the Registrar, from whom further particulars may be obtained. Ref.: CV/N.

THE LABORATORY OF BACTERIOLOGY of Cornell University invites applications for Teaching and Research Assistantships. Applicants must be qualified to work for an advanced degree (M.S. or Ph.D.) in Bacteriology, although prior bacteriology training is not required. Stipends are usually in the range of $2,200 to $3,200 per annum. Applications for the academic year 1961-62 should be completed by April.—Further details and information may be obtained from Professor E. A. Delwiche, Laboratory of Bacteriology, Cornell University, Ithaca, New York, U.S.A.

TECALEMIT LIMITED, PLYMOUTH, Devon, have a vacancy for the post of Physicist or Technologist in their Laboratory for testing non-metallic materials. Applications are invited from men under 30 years of age with a University degree who have not less than three years industrial or research experience, preferably connected with one of the following materials: plastics, filter media, rubber and adhesives. The selected candidate will find interesting and varied work in the congenial atmosphere of a modern and expanding factory. The Company offers a contributory Pension-Life insurance scheme, together with a comprehensive ranee of welfare and recreational activities.—Please apply, in strictest confidence, to the Personnel Manager, giving age, together with qualifications, experience and present salary.

PHYSICIST

An attractive post with good prospects exists for a young Assistant Technical Officer (physicist) in the Research and Development Department, of Imperial Chemical Industries, Ltd., Stevenston, Ayrshire. He will work on the evaluation and testing of the large established range of silicone products including rubbers and resins, and on experimental silicone products. The successful candidate will be in charge of a team.

Wide experience of classical physics is needed and, preferably the candidate should have some specialization in electronics. The minimum qualification, in addition to experience, is the Higher National Certificate or its equivalent. The right man will have good prospects of promotion to Technical Officer status.

The Company operates a five-day week, a contributory Staff Pension Fund and a Profit-Sharing Scheme.

Applications, giving age, qualifications and previous experience, should be sent to

The Staff Manager,
Imperial Chemical Industries, Limited,
Nobel Division,
460 Sauchiehall Street, Glasgow, C.2.

A SENIOR MICROBIOLOGIST

is required at Worthing to take charge of the Microbiological Laboratory associated with Antibiotic Production.

Applicants should be qualified and preferably have had previous experience of Microbioloutcal Assay methods, sterility testing and culture maintenance techniques.

Good salary, non-contributory pensions and staff profit sharing schemes in operation.

Apply in writing, giving details of age, qualifications and experience to: Personnel Officer, Beecham Research Laboratories Ltd., Clarendon Road, Worthing, Sussex.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY GLASGOW

SENIOR LECTURESHIP IN INORGANIC CHEMISTRY

Applications are invited for the above post in the Department of Chemistry. The appointment will date from September 1, 1961, and will be on the salary scale £1,975 by £75 to £2,275 with family allowances and F.S.S.U. benefits.

Applications should be lodged with the Secretary of the College, George Street, Glasgow, C.1 (from whom further details may be obtained), not later than March 15, 1961.

UNIVERSITY OF CAMBRIDGE

Applications are invited for a University Demonstratorship in Metallurgy: appointment will be from October 1, 1961. Applications close on March 31, 1961.

Details of duties, salary, etc., may be obtained from Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge.

COUNTY BOROUGH OF ROTHERHAM EDUCATION COMMITTEE

ROTHERHAM COLLEGE OF TECHNOLOGY
DEPARTMENT OF PHYSICS

Assistant Lecturer, Grade B (man or woman), to teach Physics in courses leading to National Certificates in Applied Physics, Engineering, Metallurgy and Chemistry and to the General Certificate of Education at Ordinary and Advanced Levels. Man, £700 by £27 10s. by £37 10s. to £1,150; woman, £630 by £22 by £26 to £920 plus equal pay increments to £1,150. Plus additions for certain qualifications.

Application forms and further particulars may be obtained from the undersigned to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

R. BLOOMER,
Director of Education.

Education Offices,
Rotherham.

NEW COLLEGE
OXFORD
RESEARCH FELLOWSHIPS

The College proposes, if candidates of sufficient merit present themselves, to elect to three Research Fellowships.

The Grocer's Company Research Fellowship, which has a stipend of £900 a year, is available for a candidate who wishes to work in one of the biological sciences.

The Guinness Research Fellowship, which has a stipend of £950 a year, is available for a candidate who wishes to work in one of the biological or physical sciences but, where candidates of equal merit present themselves, a candidate in one of the biological sciences will be elected.

The Kennedy Research Fellowship, which has a stipend of £900 a year, is offered without any restriction on the field in which the successful candidate would be expected to work.

Each Fellowship will be tenable from October 1, 1961, for three years in the first instance with a possibility of renewal for not more than two years.

Rooms, etc., F.S.S.U. For further details apply the Warden, New College, Oxford.

COMMONWEALTH MYCOLOGICAL INSTITUTE

Applications are invited for the post of Abstractor. Candidates should have sound knowledge of German and Dutch and ability to abstract in English from these languages. Scandinavian and/or Spanish and Portuguese languages an added qualification. Knowledge of microbiology and/or botany an advantage. Salary according to qualifications and experience in the range £640 to £1,325 per annum.

Apply in writing, the Director, Ferry Lane, Kew.

NEW COLLEGE
OXFORD
THE STONE-PLATT STUDENTSHIP

The College proposes, if a candidate of sufficient merit presents himself, to elect to the Stone-Platt Studentship without restriction of subject. The Studentship will be tenable from October 1, 1961, for two years in the first instance with a possibility of renewal. Stipend of £750 a year.

For further details apply to the Warden, New College, Oxford.

TIN RESEARCH INSTITUTE

Graduate required to undertake research on the chemistry of metal surfaces. Minimum starting salary £800 per annum. Publication of research is encouraged and opportunity exists for the submission of work for higher degrees. F.S.S.U. benefits.

Applications to the Director, Tin Research Institute, Fraser Road, Greenford, Middlesex.

RESEARCH INSTITUTE (ANIMAL VIRUS Diseases), Pirbright, Surrey, invites applications for Assistant Experimental Officer or Assistant (Scientific) in Biophysics Department. Work involves application of physical-chemical methods (electron-microscopy, electrophoresis, ultracentrifugation etc.) to study of viruses, mainly of foot-and-mouth disease. Applicants should have, or be studying for, H.N.C. Salary dependent on age and qualifications in Assistant Experimental Officer scale £625 at age 22 rising to £983, or Assistant (Scientific) scale £453 at age 22 rising to £723.

Applications to the Secretary.

STUDENT TECHNICIANS REQUIRED IN the Department of Pathology, Connaught Hospital, Walthamstow, E.17. Facilities for training and study for the examinations of the I.M.L.T. Salary in accordance with Whitley scales.—Applications, with copies of two testimonials, should be sent to Secretary, Forest Group H.M.C., Langthorne Road, E.11.

TECHNICIAN REQUIRED BY ZOOLOGY Department, University College London, Gower Street, W.C.1, to assist in research of Professor P. B. Medawar and his group on transplantation. Previous experience in this field not essential. G.C.E. (A) level in either biology or zoology desirable.—Application forms from Secretary, quoting Zoology/1.

ROYAL VETERINARY COLLEGE. Laboratory Technician required in the Department of Physiology. Salary scale, £490 to £675 per annum plus London weighting. Qualifications allowance payable additionally in certain circumstances. Superannuation scheme.—Applications, with full particulars of age and experience, to Assistant Secretary, Royal Veterinary College, Royal College Street, London, N.W.1.

APPOINTMENTS WANTED

RESEARCH MANAGER OF PHARMAceutical Company, ideas, talent, initiative and drive stifled by unimaginative Board, seeks new appointment. Ph.D., F.R.I.C., A.R.C.S., 40 years old, 20 years experience chemotherapeutic research. Preferably Cheshire area.—Box 949, T. G. Scott and Son, Ltd., 1 Clement's Inn, London, W.C.2.

FOR SALE AND WANTED

ALMOST ANY BACKNUMBERS AND volumes of *Nature* wanted. Also learned and scientific journals, transactions of most kinds. Further: *Notes and Queries*, the *Annual Register*, *Quarterly Review*, *Palmer's* and/or the *Official Index* to the *Times*, *British National Bibliography*, *English Catalogue of Books*, *Journal Royal Philosophical Society*, *Royal Statistical Society*, etc.—H. Pordes, 138 New Cavendish Street, London, W.1. MUSeum 5250.

pH METER. MUIRHEAD BATTERY operated portable pH meter, Model Number D449A complete with batteries, glass electrode (plus one spare), and buffer tablets.—Offers to the Administrative Officer, Nutritional Research Unit, Huntingdon. Telephone Huntingdon 1122.

GRANTS & SCHOLARSHIPS

NATO GRANTS

for participation in the
CANADIAN THEORETICAL PHYSICS SEMINAR

Two grants of value $750 (£268) each are being offered by the North Atlantic Treaty Organization on a competitive basis to students of theoretical physics from NATO countries to attend the Second Quadriennial Theoretical Physics Seminar of the Canadian Association of Physicists to be held August 13 to September 9 at the University of Montreal. The seminar features lecture series by outstanding theoretical physicists as well as informal discussion on physics.

For further information and application forms write Dr. D. D. Betts, Department of Physics, University of Alberta, Edmonton, Canada. Deadline for applications is April 15.

POSTGRADUATE STUDENTSHIPS IN U.S.S.R. 1961–62

Applications are invited for twenty scholarships for study at Soviet universities for the academic year 1961-62. These awards are open to postgraduate students currently engaged in study or research at universities or equivalent institutions. Undergraduates now in their final year may be considered. Applicants must be of British nationality and have a working knowledge of the Russian language.

Outline particulars and application forms, for which a stamped, self-addressed foolscap envelope should be sent, are obtainable from the British Council, 65 Davies Street, London, W.1. Completed application forms must be returned to the British Council by February 24, 1961.

NUFFIELD FOUNDATION

BIOLOGICAL SCHOLARSHIPS AND BURSARIES

The Nuffield Foundation, as part of its programme for the advancement of biological studies, is prepared to offer for the academic year 1961-62 a limited number of scholarships and bursaries to enable persons who have graduated in physics, chemistry, or mathematics or engineering, but who have had no training in a biological subject, to receive such training in biology as will enable them in due course to undertake research and teaching in the United Kingdom in the biological sciences. The scholarships, which are senior awards, are intended for persons who have already undertaken some postgraduate research in their own subject. The bursaries are intended to enable those who have recently graduated to complete a course of training in biological subjects including, if considered necessary, a full honours degree course in biology. In the case of both scholars and bursars the Foundation will pay the cost of university and/or college fees in addition to a maintenance award. Graduates of universities in the United Kingdom, of either sex and preferably between the ages of 22 and 35, are eligible to apply.

Applications for awards in 1961 must be received before April 1, 1961, by the Director, the Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1, from whom full particulars and application forms can be obtained.

L. FARRER-BROWN, C.B.E.,
Director of the Nuffield Foundation.

LECTURES AND COURSES

ADVANCED COURSE ON RADIATION PROTECTION

held at the
HARWELL REACTOR SCHOOL

Fourth Course— April 19 to July 18, 1961
Fifth Course—Commencing late in 1961

The Course is intended for persons of good academic standing who are working in or entering the field of Radiation Protection. It is especially concerned with the protection of the workers in installations having high levels of radioactivity, such as radiochemical plant, high level laboratories and reactors, and with the control of waste products. The theoretical part of the course, which includes the basic scientific principles, consists of about 100 lectures; the majority of these are by members of the staff of the United Kingdom Atomic Energy Authority, but specialist topics are covered by members of the staffs of other bodies, including among others the Medical Research Council, the Agricultural Research Council, and the Royal Institute for Cancer Research. Practical work is held in the laboratories of the Reactor School, and in various laboratories and installations in the Atomic Energy Research Establishment. There is a comprehensive programme of visits, including a short tour of the factories of the United Kingdom Atomic Energy Authority at Windscale and Springfields.

For further information and forms of application, write to:

The Manager, Reactor School,
Atomic Energy Research Establishment,
Harwell, Didcot, Berkshire.

LANCHESTER COLLEGE OF TECHNOLOGY

COVENTRY
DEPARTMENT OF APPLIED PHYSICS

Short Course on
"RECENT ADVANCES IN NON-DESTRUCTIVE TESTING"
February 23-24, 1961

A short course for physicists and engineers will be held on Thursday and Friday, February 23 and 24, 1961, and will include the following topics: Radiography, Internal Friction, Ultrasonics, Eddy Currents, Surface Crack Detectors, Electromagnetic Methods of Quality Control, Fluoroscopy and Economics.

Fee: £1 2s.

Full particulars and forms of application from the Head of the Department of Applied Physics, Lanchester College of Technology, Priory Street, Coventry.

NORTHERN POLYTECHNIC

HOLLOWAY ROAD, LONDON, N.7

INFRA-RED SPECTROSCOPY

A course of four lectures will be given on Tuesdays from 6.30-8 p.m. commencing on March 7, 1961.

Scope: Introduction and scope of infra-red spectroscopy and infra-red spectra of phosphorus and steroid compounds. Lectures on instrumentation including interference filters, the KBr region, linear scale expansion equipment and Golay and other modern detectors. At the last meeting, several well-known instrument makers will be giving demonstrations of various equipment and accessories.

Fee for the Course 11s.

Apply now, enclosing fee, to Dr. W. Gerrad, Head of the Department of Chemistry.

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SILICA CONES AND SOCKETS. VITREOsil silica tubing, polished silica discs and glazed sheet always in stock.—Custom built silica/quartz apparatus from Jencons. The Silica Centre, Mark Road, Hemel Hempstead, Hertfordshire. Boxmoor 4641.

BRIGHT'S REMOTE COLD CONTROLLED Microtome (cryostat) custom built for producing frozen sections for rapid diagnostic biopsies.—Full information on request to Bright's Refrigerator Service Ltd., 399 Portobello Road, London, W.10. LADbroke 4153.

MICROSCOPES. GOOD SECONDHAND Microscopes from £10 to £100, various makes and types for medicine, biology, pharmacy, botany. Tested by the specialists Wallace Heaton Ltd., 127 New Bond Street, London, W.1.

BRIGHTON TECHNICAL COLLEGE

AUTOMATIC PROGRAMMING INFORMATION CENTRE

announces an

ALGOL 60 PROGRAMMING SCHOOL

to be held at

BRIGHTON TECHNICAL COLLEGE

April 5 and 6, 1961

Tutors:	E. W. DIJKSTRA	(Matermatisch Centrum, Amsterdam)
	F. DUNCAN	(The English Electric Co., Ltd.)
	P. LANDIN	(London)
	P. NAUR	(Regnecentralen, Danish Institute of Computing Machinery, Copenhagen)
	M. WOODGER	(National Physical Laboratory)

The object of the school will be to provide those attending not only with an opportunity to hear authoritative explanations of the language, but also, to write short exercise programmes or sections of programmes in ALGOL under expert supervision, and to discuss difficulties with the tutors in "Question and Answers" sessions.

Fees (not including accommodation): Subscribers to A.P.I.C.:
THREE POUNDS PER STUDENT

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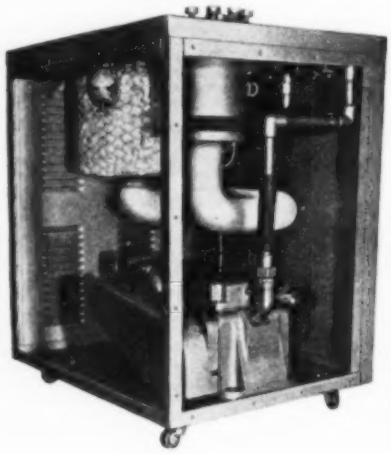
FIVE POUNDS PER STUDENT

Full details may be obtained from the Automatic Programming Information Centre, Department of Mathematics, Brighton Technical College.

RESIN IMPREGNATION

of wire-wound components under vacuum



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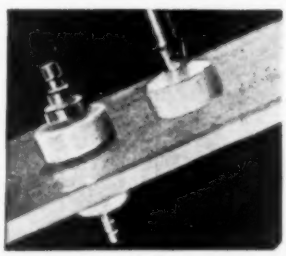

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CHASSIS HOLE. .156 in. diameter.

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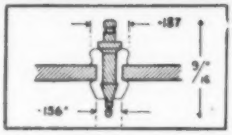

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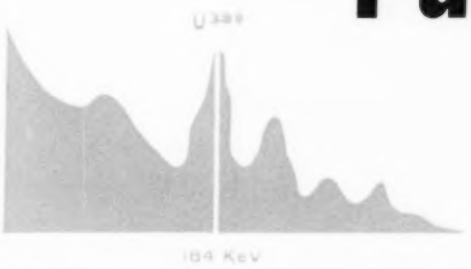

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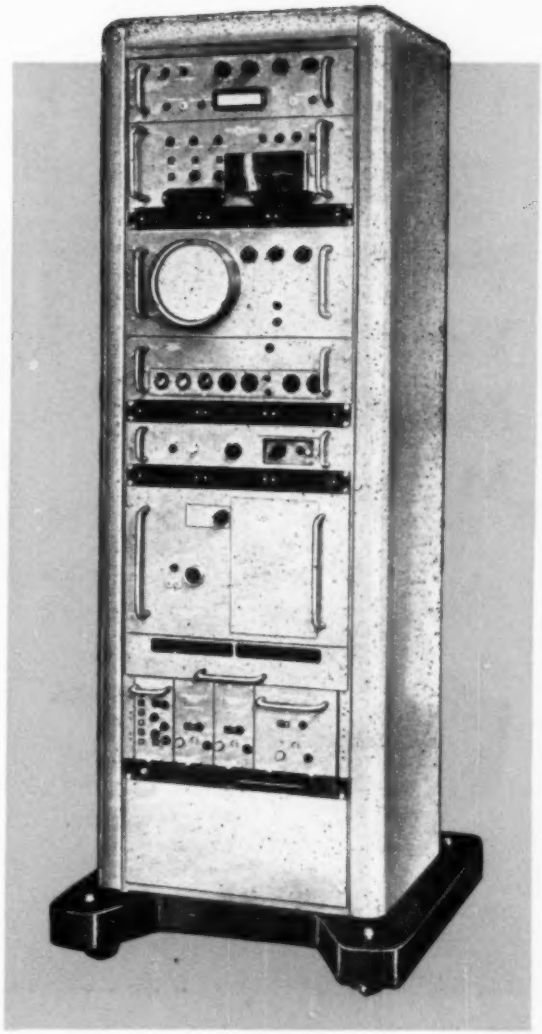

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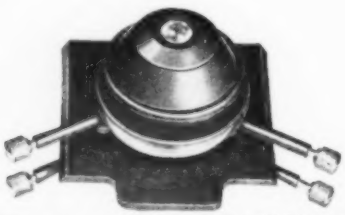

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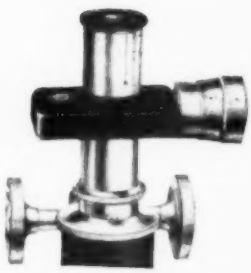

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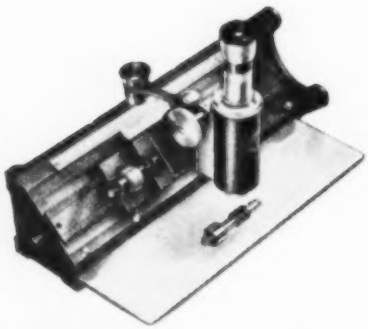

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